

Technical Facilities and Capabilities Assessment Report

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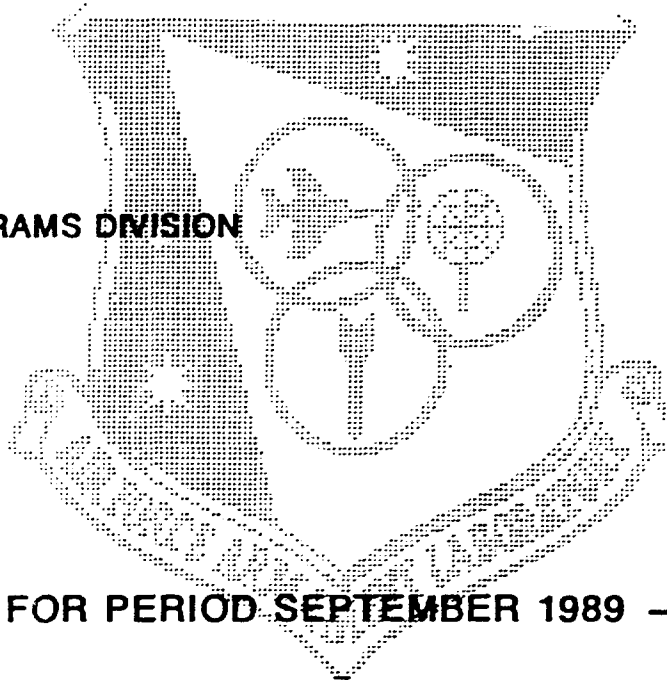
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JUNE 1990



FINAL REPORT FOR PERIOD SEPTEMBER 1989 - SEPTEMBER 1990

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AIR FORCE ARMAMENT LABORATORY

Air Force Systems Command ■ United States Air Force ■ Eglin Air Force Base, Florida

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PAUL D. SHIREY
Chief, Plans and Programs Division

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SECTION I

AIR FORCE ARMAMENT LABORATORY

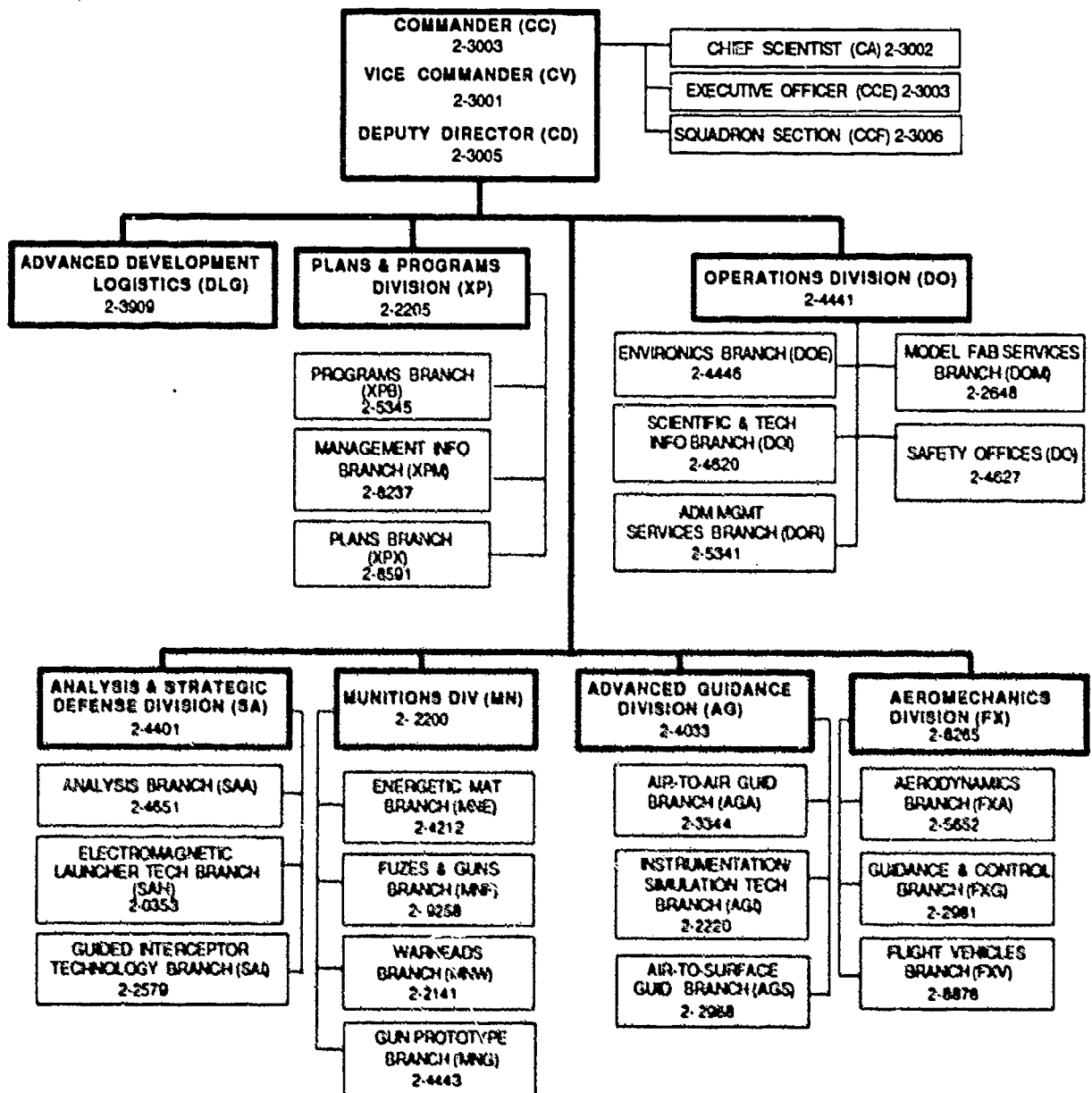


FIGURE 1. ORGANIZATIONAL CHART

The Air Force Armament Laboratory (AFATL) provides the technology base for future armament systems and supports the other elements of the deputy commander for research, development, and acquisition. The Air Force Armament Laboratory Organization consists of the Commander, the Vice Commander, Deputy Director, Chief Scientist, an executive officer, a squadron section, and six operating divisions. Four divisions are product oriented conducting basic research, exploratory development, and advanced development. Of the other two, one provides planning, programming, and management information and one provides general operating support. Also integral to the laboratory is Advanced Development Logistics, which provides support.

SECTION II

ADVANCED GUIDANCE DIVISION

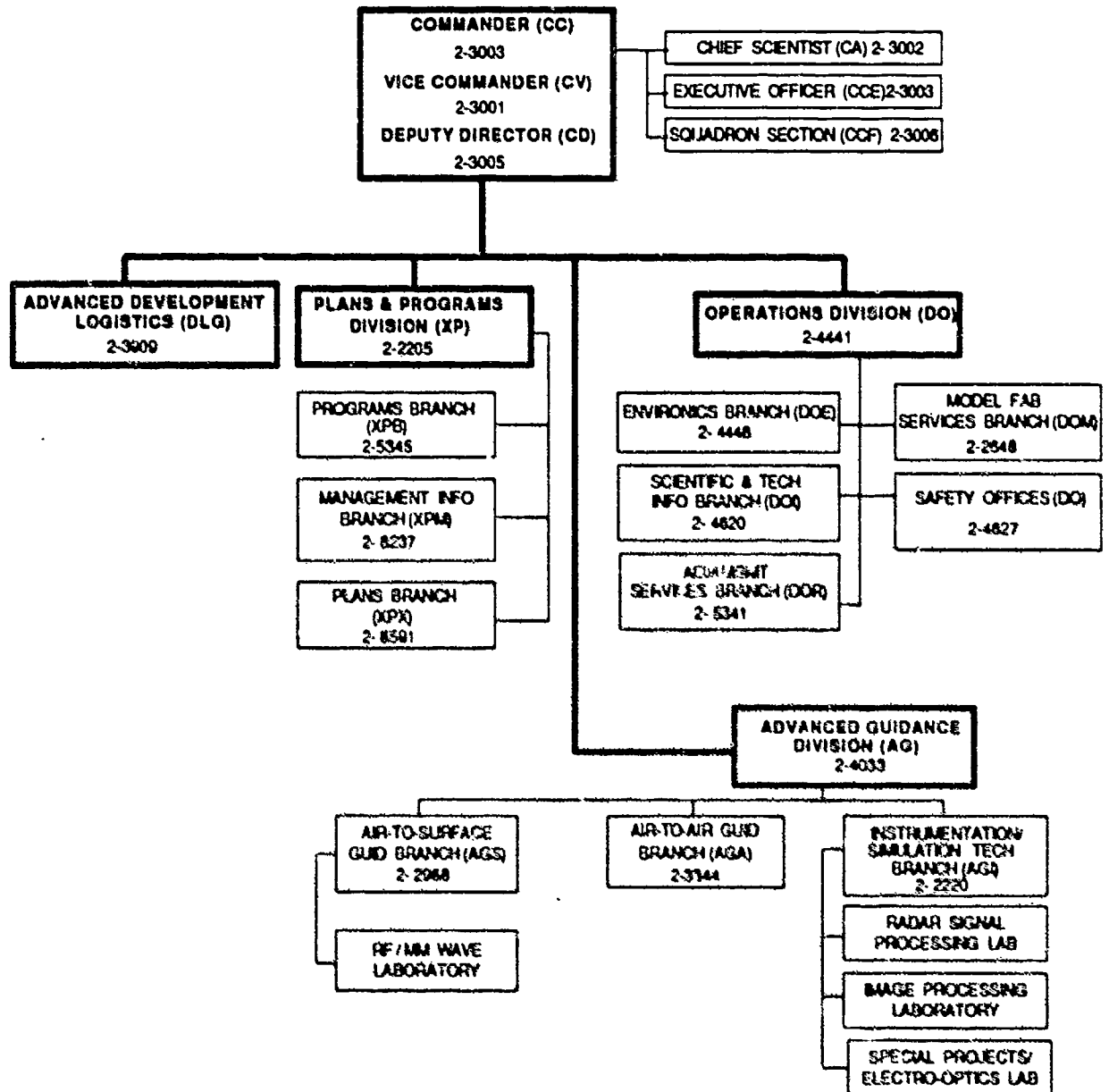


FIGURE 2. ORGANIZATIONAL CHART

1. Mission Overview

The Advanced Guidance Division (AG) provides research, development, and technical feasibility demonstrations of Air-to-Surface terminal guidance sensors and seekers, Air-to-Air missile guidance technology, and missile system simulation and analysis; maintains in-house facilities and evaluation capabilities of sensors and seekers for terminal and midcourse guidance; and operates the RF/MM Wave Laboratory, Image Processing Laboratory, Radar Signal Processing Laboratory, and the Special Projects/Electro-optics Laboratory.

2. RADIO FREQUENCY/MILLIMETER WAVE LABORATORY

The Radio Frequency (RF) and Millimeter Wave (MMW) Laboratory is chartered to develop and evaluate radar and millimeter wave guidance technology through 94GHZ. To perform this important function, the facility is separated into three sections: the main RF/MMW Laboratory, the Penthouse facility, and the AG Test and Instrumentation (AGIT) Tower facility.

The Laboratory consists of 119 square meters of working space which contain test benches used for calibration and measurements, main power facilities for support of the test equipment used in the Laboratory, Penthouse and Tower, a test stand for passive countermeasures evaluations, the APG-66 radar system, and limited electronic parts bench stock. The test equipment utilized in the Laboratory consists of a vector network analyzer, a scalar network analyzer, a spectrum analyzer, power meters, analog sweep generator, standard gain antennas for Ka and W bands, dual polarized antennas for Ka and W bands, a plastic feed monopulse antenna for Ka band and connector tool kits for building RF cables. The most recent addition to the Laboratory is an F-16 derived 10GHZ search and track radar used to track aerial targets with limited ground tracking capability. The system is used extensively by Air-to-Air programs for the development of future seeker designs.

The Penthouse is located at roof level on Building 13A at Eglin Air Force Base (AFB), Florida. There are 13.5 square meters of work area and a southern view of Eglin AFB is provided through sliding glass windows. The view allows the Laboratory engineers the advantage of scanning the surrounding areas with various antennas for target acquisition and measurement evaluation. Both power and signal cabling is connected to the Laboratory through cable conduits. A concrete pad is installed in the floor for mounting antennas and pedestals to ensure precise measurements. Additionally, a freight elevator services the Penthouse from the ground floor to facilitate the movement of heavy equipment.

The AG Test and Instrumentation Tower (AGIT) is located on top of Building 13A and forms an extension of the Penthouse elevator shaft. The Tower is 10.6 meters above the building's roof line and has a 3M by 3M working floor space. The work space allows for a 360-degree field of view when operating a radar tracking antenna such as that used in the 94GHZ beacon currently housed in the AGIT.

The RF/MMW Laboratory has just recently completed the AGIT in which the 94GHZ monopulse radar is housed. This radar system is powered by and connected to the main Laboratory test equipment. The main shaft elevator services the Tower for movement of heavy equipment. The addition of the Tower has improved Eglin's capability to perform extensive evaluation and development of advanced seeker technology.

A countermeasure test fixture has also been installed to aid in determining the radar reflectivity of various materials. This is being used, for example, to identify special netting materials to be used for covering field vehicles in order to prevent their detection by enemy radars.

Future development of the Laboratory is being considered to include bistatic measurement utilizing the Tower. The effort to modernize the Tower is expected in the next year. The bistatic radar would be used to develop a means by which the radar system would utilize the enemy's own radar (unknown to him) to track his targets. The advantage would be to develop a seeker that does not radiate during tracking. A 5-year plan projects the development of a seeker emulator capable of operation in the MMW frequencies of both 35 and 94GHZ. It would include all the algorithms necessary to facilitate the emulator. Additional areas are being investigated to allow for future growth of ground vehicle tracking, including identification of a land mass that could contain a tower for radar transmission/tracking.

The point of contact is Mr. John Walker, AFATL/AGS, Autovon 872-4631.

3. THE IMAGE PROCESSING AND RADAR SIGNAL PROCESSING LABORATORY

The Image Processing Laboratory (IPL) and the Radar Signal Processing Laboratory (RSPL) provide the Air Force Armament Laboratory (AFATL) with computational resources for image and signal processing. Much of the work in AFATL involves radar, infrared, and visible spectrum images. The twin laboratories are an excellent means of support for this work.

The IPL and the RSPL share a high degree of similarity. This is advantageous for computer users since many classified operations are performed in the laboratories. When the IPL is unavailable due to classified operation or system maintenance, users can perform their work in the RSPL, and vice-versa. Both laboratories use Digital Equipment Corporation (DEC) VAX computers and the DEC operating system Virtual Management System (VMS). Both laboratories have Gould IP8500 image processing systems and high definition Red-Green-Blue (RGB) color graphic workstation monitors. There are four magnetic tape drives and more than a half-dozen VT340 color-graphic terminals in each laboratory. Each laboratory has a DEC LN03 laser printer, a DEC LXY-22 line printer and a color graphics Toyo TPG-4300 Color Thermal-Wax printer. Both laboratories have stand-alone Tektronics workstations.

The RSPL currently uses two computers in a clustered configuration as its central processing components. Unique to the RSPL is a Numerix-432 array processor, Aptec IOC-24 high-speed, intelligent data bus, and a Write-Once-Read Many (WORM) optical disk drive. The RSPL has 2.5 Gigabytes of on-line disk storage (excluding the optical disk drive capacity).

The IPL's computing power is centered around a VAX 8650 computer, one of the more powerful computers that DEC manufactures. The 8650 offers approximately four times the raw computing power of the RSPL's computers. The IPL has over five Gigabytes of on-line disk storage capacity. Unique to the IPL is a video rack containing U-Matic and VHS formatted video recorders, a color RGB video camera, an RGB-to-composite encoder, a composite-to-RGB directory, and video signal controllers. The video rack and its peripherals are used to import and export images to and from the computer system.

The laboratories generally use Fortran, Ada, Basic, OPS5, Pascal, LISP, and Macro programming languages. Specialized image processing languages/environments are also available. Among these packages are Library of Image Processing Software (LIPS), Cellular Array Processing Software



FIGURE 3. RADAR SIGNAL PROCESSING LABORATORY



FIGURE 4. SIGNATURE MODELING OF F-15

(CLOCKWISE FROM UPPER LEFT: ORIGINAL PHOTO, MULTIFACETED MODEL, R F. MODEL, I.R. MODEL)

(CAPS), and in-house image processing utilities. This image processing software gives the users the ability to rotate, save, import, export, color and filter digital images once an image is on the system.

The IPL and the RSPL are accessible over the base Ethernet. This allows users to logon to the IPL and the RSPL from a terminal server connected to the Ethernet or from another computer system connected to the Ethernet (node).

Images can be imported to the system from magnetic tape and from 5 and 1/4 inch or 3 and 1/2-inch floppy disks, by copying files over the Ethernet, from VHS or U-Matic tape, and from digitizing pictures of images. Images can be exported in the same manner.

The quality of hard copy printing facilities is high. In addition to the printers listed previously, there is also a Matrix 4007 camera with instant development capability. With this equipment, users prepare many graphs, charts, and overhead transparencies for briefings and presentations.

Plans are currently underway to acquire a second VAX 8650 for use in the RSPL. The 8650 will replace the RSPL's current computers, the VAX/750 and VAX/785. The computer language C has been ordered for the RSPL. The point of contact is Mr. Lee Prestwood, AFATL/AGI, Autovon 872-3338.

4. SPECIAL PROJECTS/ELECTRO-OPTICS LABORATORY

The Special Projects/Electro-optics Laboratory provides the capability for investigating various types of state-of-the-art transducers and sensors used in aircraft and weaponry instrumentation systems. This laboratory utilizes advanced technologies; i.e., lasers, photonics, velocimetry etc., to assist in the development of specialized sensors used to obtain non-intrusive pressure wave front characteristics, non-contact flight dynamic measurements and other parametric measurements associated with high performance weaponry.

This Laboratory is investigating the use of high speed, low light level video systems to measure flutter responses of captive carry weapons and the host aircraft. This system and other optical sensing elements are being evaluated to determine the feasibility of using this technology for accurately characterizing the minute transient moments that occur at weapon release. Thin film piezo-electric material, manganin resistive devices, optical modulation cubes, and phase conjugation crystals are some of the materials being evaluated for use as parametric measuring devices.

Formally known as the Laser/Electro-Optics Seeker Evaluation Facility, this laboratory was originally established in 1971 to evaluate the performance of optical missile guidance systems and to develop and maintain the technical expertise required in the development of electro-optical and laser guidance systems. In addition to their currently limited role of instrumentation, this laboratory still provides a capability to verify and evaluate seeker performance and sensor technologies. Present work in the infrared field involves polarization characterization of materials to be used as filters in optical computers.

The facility consists of a 60-foot long room constructed to comply with laser operation safety rules and a general purpose electronic laboratory, both of which are certified by the Eglin Ground Safety Office/Base Hospital for such use. In addition to a complement of general purpose test equipment; lasers (HeNe, ND:YAG, Argon, CO₂), detectors, blackbodies, laser simulators, sensors, optical benches and laser range and pulse characteristic simulators are available. The facility can be computer controlled and may be interfaced with the Image Processing Laboratory to utilize their digital signal processing algorithms.

Future efforts being undertaken by this facility are in the areas of fiber optics and photonics applications for instrumentation. The laboratory currently possesses the equipment and raw material necessary to conduct fiber optic research and is in the process of developing an expertise in this field.

The point of contact is Mr. Howard C. McCormick, AFATL/AGI, Autovon 872-4043.

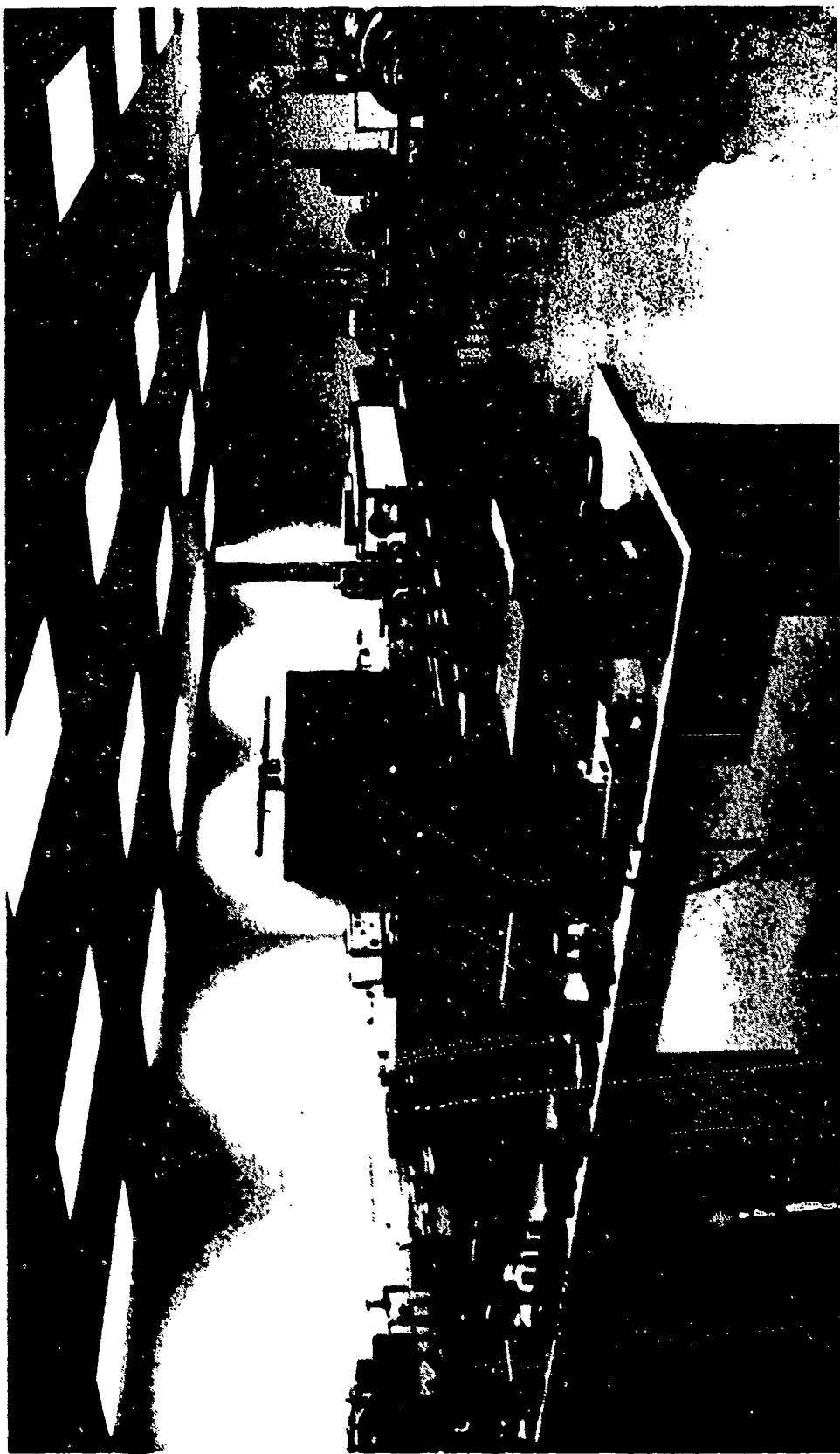


FIGURE 5. SPECIAL PROJECTS/ELECTRO-OPTICS LABORATORY

SECTION III

MUNITIONS DIVISION

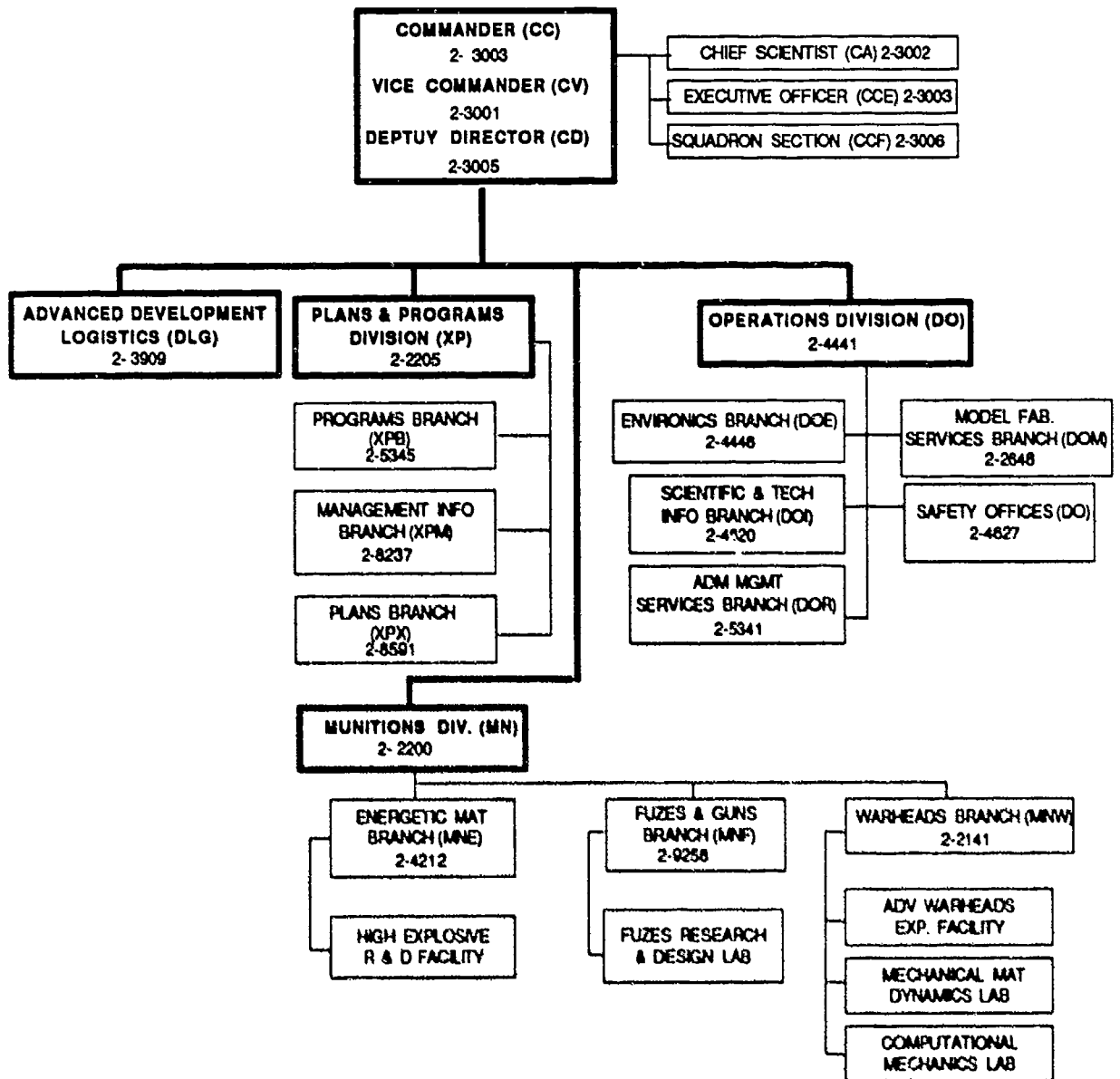


FIGURE 6. ORGANIZATIONAL CHART

1. Mission Overview

The Munitions Division (MN) directs and conducts basic research, exploratory development, and advanced development of fuzes, warheads, bombs, submunitions, guns, ammunition, and explosives and operates the High Explosive Research and Development (HERD) facility, the Advanced Warheads Experimentation Facility (AWEF), the Fuzes Research and Design Laboratory, the Mechanical Materials Dynamics Laboratory, and the Computational Mechanics Laboratory in support of Air Force and Research and Development (R&D) programs for other Department Munitions Programs of Defense (DOD) agencies.

2. HIGH EXPLOSIVES RESEARCH AND DEVELOPMENT (HERD) FACILITY

The High Explosives Research and Development (HERD) Facility was established to provide a modern in-house high explosive RDT&E capability. It has been operational since 1970.

The mission of the facility is (1) to provide explosives research and development support to organizations within the Air Force, especially to those within the Munitions Systems Division, (2) to tailor explosives to meet specific Air Force needs and develop explosive mixing and loading techniques in support of Air Force munitions development programs, (3) to characterize and evaluate explosive systems, (4) to provide necessary background data in explosives chemistry and detonation physics, and (5) to support explosives research and development programs of other US, Foreign Government and Industry Contracting agencies, when special and unique expertise is required.

The HERD Facility consists of three laboratories. The laboratories include the Properties Laboratory, The Processing Laboratory, and the Dynamics Laboratory. These laboratories function as an integral unit capable of a complete spectrum of explosives RDT&E.

The HERD Facility is unique within the DOD because the three laboratories, each with its own capabilities, are collocated. Experimental formulations meeting necessary chemical and physical criteria are developed in the Properties Laboratory. The formulations are mixed, machined, and loaded in the Processing Laboratory and the detonation properties determined in the Dynamics Laboratory. Experimental formulations can be evaluated through the stages of scale up from small scale chemical and physical testing to pilot plant scale mixing and loading through performance testing in an all-up munition.

a. Direct Synthesis of Explosives.

(1) Properties Laboratory: The Properties Laboratory is a research area that formulates small quantities of explosives and has the capability to determine the chemical and physical properties of these explosive formulations. The main thrust of the research is toward the development of insensitive and high performance explosives. The objective of the research is the development of explosives which are insensitive to shock, impact, and temperature. Munitions using these explosives will therefore be able to survive these stimuli and not mass detonate in storage areas. The properties laboratory includes a complete inventory of equipment for chemical analysis both qualitative and quantitative. This equipment supports a variety of tasks including environmental assessment and foreign weapons analysis.

The types of testing performed in the Properties Laboratory support the research and scale-up of insensitive explosive:



FIGURE 7. DIFFERENTIAL SCANNING CALORIMETER (DSC) IN THE PROPERTIES LABORATORY
(CHARACTERIZATION OF NEW EXPLOSIVE FORMULATIONS)

- a. Thermal analysis to determine the thermal properties of explosives and explosive formulations. Kinetics of decomposition must be determined to enable scale up and model prediction studies.
- b. Compatibility testing to determine if explosive material can be used in conjunction with other materials.
- c. Accelerated aging to predict storage life for explosive materials to meet required long term (15-20 years) storage.
- d. Quality control analyses such as determination of density, viscosity, and composition are determined on ingredients as well as formulations.
- e. Sensitivity testing such as impact sensitivity, vacuum thermal stability, and chemical reactivity, accelerated rate calorimetry, and one dimensional time to explosion are determined for all formulations.
- f. Binder development for plastic bonded and melt castable binder explosive systems.
- g. Kinetic studies to aid in the determination of compatibility, storage life predictions, and cookoff studies for correlation of small scale tests to large scale tests.
- h. Characterizations of ingredients used in explosive formulations using infrared spectroscopy; thin layer, liquid, and gas chromatography; bomb calorimetry; hot stage microscopy; elemental analysis; nuclear magnetic resonance (NMR); and classical wet chemistry techniques.
- i. Direct synthesis of explosives and correlation of structure to sensitivity.

(2) Processing Laboratory: The Processing Laboratory provides high explosive processing and loading support for the Air Force nonnuclear weapons development programs. A recently completed Military Construction Project (MCP) has renovated and expanded this pilot plant facility's capabilities. A significant increase in storage facilities along with the addition of a 500-ton press, vacuum tumble dryer, and increased separator, scale, and oven capacity has been accomplished. The facility can load experimental munitions with up to 100 gallons of an explosive formulation (standard or developmental) for performance evaluation. Processing techniques for loading Air Force munitions are also developed.

The processing and loading capabilities include the following:

- | | | |
|------------------|-------------|---------------|
| - Melt Casting | - Cutting | -Hand Packing |
| - PBX Mixing | - Machining | |
| - Vacuum Casting | - Pressing | |



FIGURE 8. HERD PROCESSING LABORATORY'S CENTRAL CONTROL ROOM
FOR REMOTE CONTROLLED EXPLOSIVE OPERATIONS



FIGURE 9. THE VARIAN LINATRON 1000A, CAPABLE OF GENERATING 1000 RADS PER MINUTE, IS LOCATED IN THE PROCESSING LABORATORY'S X-RAY FACILITY. THE VARIAN LINATRON PRODUCES RADIOGRAPHS THAT ARE USED FOR NONDESTRUCTIVE TESTING OF MUNITIONS LOADED WITH EXPERIMENTAL EXPLOSIVE FORMULATIONS.

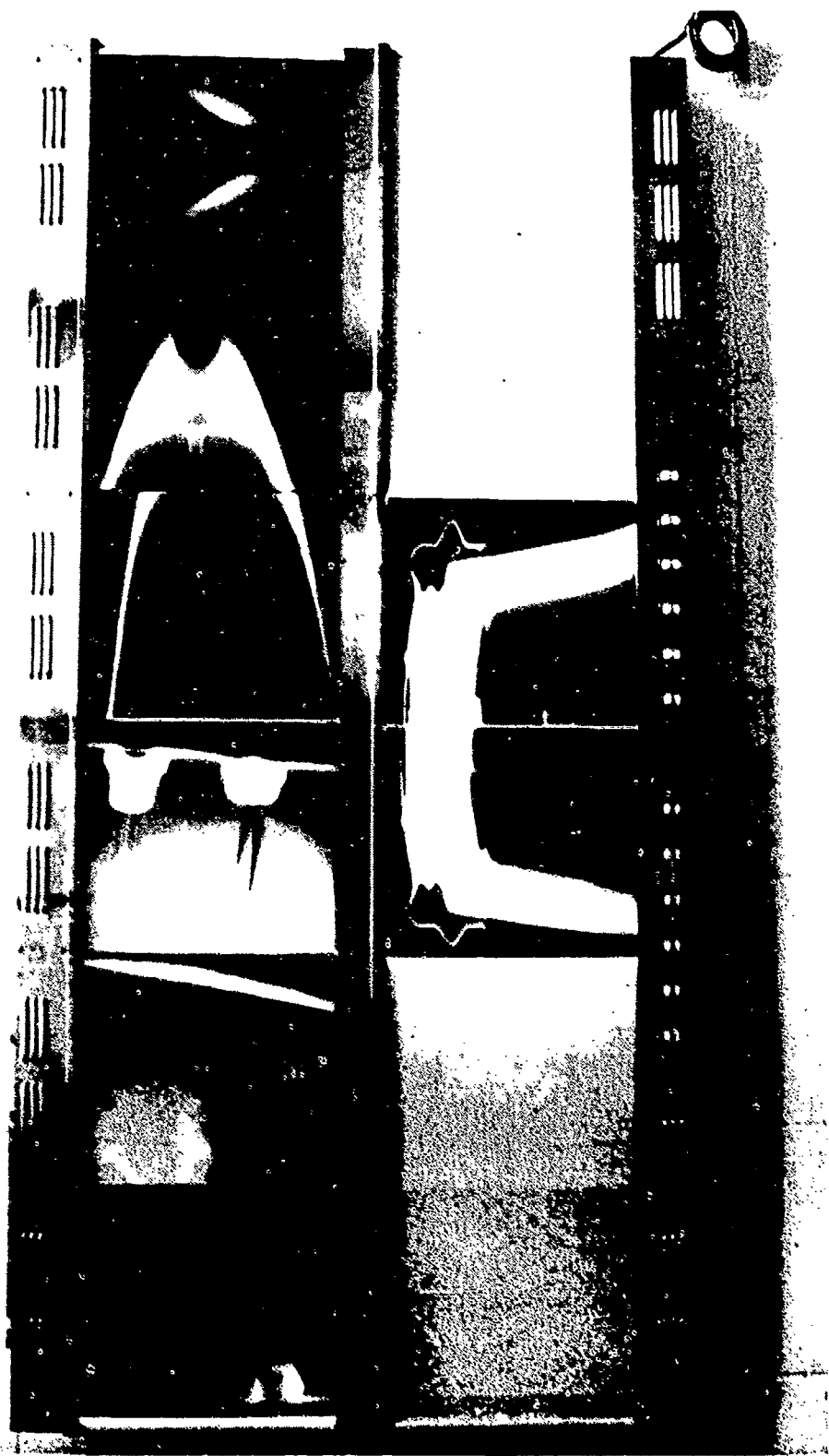


FIGURE 10. RADIOGRAPHS OF MK84 (2000-POUND) BOMB

Experimental formulations can be tested for mechanical properties under environmentally controlled conditions. Finished products can be subjected to fluoroscopic and conventional x-ray examinations up to 6 MeV.

The majority of the Processing Laboratory equipment is operated remotely and monitored on closed-circuit television. The temperatures of all mixers, melt kettles, and ovens are monitored in the central control room.

(3) Dynamics Laboratory: The Dynamics Laboratory provides the capability to determine the performance parameters of explosive materials through sophisticated photographic and electronic techniques. The test chamber is designed to allow testing of up to 20 pounds of high explosives. Streak cameras record shock wave propagation up to 10 millimeters/microsecond, while framing cameras can allow for 35-millimeter photography at speeds of up to 10 million frames per second. Time increment measurements to within nanoseconds are recorded on fast rise and raster oscilloscopes.

Some of the specific tests conducted at the Dynamics Laboratory are as follows:

- Cylinder Expansion Test
- Small Scale Card Gap Test
- Wedge Test
- Initiation Test
- Cookoff Test
- Aquarium Test
- Plate Dent Test

The Dynamics Laboratory personnel have access to Munition Systems Division Test Range C-64A to accomplish air blast testing, bullet impact testing, large scale, gap testing, and the testing of explosive charges greater than 20 pounds. Film data are reduced with a multi-coordinate film reader/densitometer. Analytical evaluation is provided by a PDP 8E system with access to a CDC 6600 computer system at the Directorate of Computer Sciences.

The point of contact is Mr. Gary Parsons, AFATL/MNE, Autovon 872-5969.

3. ADVANCED WARHEAD EXPERIMENTATION FACILITY

As the lead organization for the development of air-delivered munitions, the Air Force Armament Laboratory at Eglin has constructed a facility to study the terminal ballistic effects of warheads and penetrators. The key resource of the Advanced Warhead Experimentation Facility (AWEF) is a unique target chamber design. The target chamber was developed by the Air Force to allow terminal ballistic testing with various types of material, including high density metals, such as depleted uranium, tantalum and tungsten. This facility will provide the Air Force and other DOD agencies the capability to study warhead and penetrator performance, while containing the effects of potentially hazardous materials. In addition to the target chamber, the facility located at Test Range Site C-64C contains several buildings to support administrative and operational functions (Figure 11).

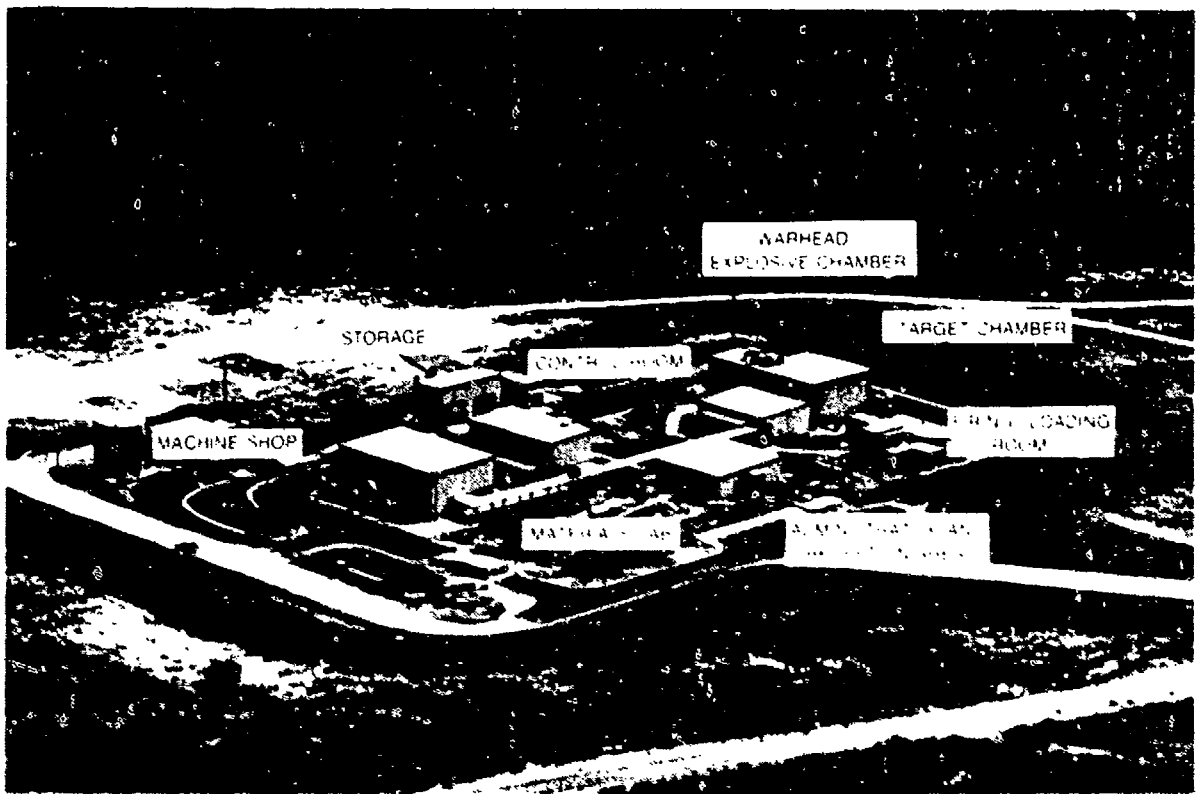


FIGURE 11. VIEW OF THE ADVANCED WARHEAD EXPERIMENTATION FACILITY



FIGURE 12. VIEW INSIDE THE TEST CHAMBER

a. Experimental Capabilities.

The AWEF will provide the capability to conduct terminal ballistic experiments with gun launched, or explosively formed penetrators (EFP). The data generated in these experiments will be assessed by engineers responsible for the development of armor and armor penetrators. Typically, terminal ballistic experiments are parametric studies to measure weapon effectiveness. The AWEF will provide the capability to study penetrator performance against various target configurations. It will provide a capability for studying shape charge jet and EFP formation. Data from behind armor debris experiments can be used to support weapon lethality studies.

b. Facility.

(1) Target Chamber. The target chamber is completely enclosed with interior dimensions of 12.2 m by 12.2 m by 6.1 m (Figure 12). The structural design criteria of the target chamber was to withstand the blast effect produced by a 50-pound charge of TNT. For safety purposes, nominal ratings will allow the detonation of 20 pounds of TNT equivalent explosive material for actual testing in the target chamber. To meet this design criteria, the walls of the chamber are made of reinforced concrete 1.22 m in thickness. The interior walls of the chamber are protected from fragment damage and blast effects by a layer of steel 100 millimeters in thickness. This room can be evacuated to 1.0 psia or pressure. A 20-ton overhead crane within the chamber provides the capabilities to lift and position various test structure; i.e. targets, blast shields, etc.

Personnel access to the target chamber is provided through a decontamination chamber. On the clean side, personnel will dress in the appropriate protective wear before entering the target chamber area. When exiting the target chamber, personnel will be monitored for possible contamination before being allowed to leave the decontamination facility.

Four tubular shaped ports, 0.91 m in diameter, provide access to the interior of the chamber for test purposes. Two of the ports are designed to provide access for research guns. The third port connects the target chamber with an adjacent warhead and explosive test chamber. The fourth port will be used as a bulk head interface for the x-ray power supplies located outside the target chamber.

(2) Control Room. The control room, which adjoins the target chamber, will house an integrated safety interface, data collection, and automated control system for the facility. Experiments will be initiated, monitored, and recorded by the system. The control system will also provide automated data gathering, data reduction, and manage safety functions for the facility. Viewing portals, looking into the target chamber, will allow the use of high speed photography and videography.

(3) Warhead/Explosive Test Chamber. Located adjacent to the target chamber, the warhead/explosive chamber was designed to provide a longer standoff distance between the warhead launch position and the target. The explosively formed penetrator (EFP) or the shape charge jet, generated by a warhead, will travel from the warhead chamber to the target chamber through a connecting tube. When the warhead/explosive chamber is opened to the target

chamber both areas can be evacuated to 1.0 psia pressure. In addition, explosive material testing can be performed in this chamber.

(4) Firing Room/Gun Pit. The firing room will house a 60-millimeter powder gun. The gun will be rail mounted so that it can be retracted into the firing room for storage and loading. When in the firing position, the gun will be brought forward, allowing the barrel to extend into the target chamber. A vacuum seal around the gun barrel has been developed to allow firing of the gun when the target chamber is evacuated. The operating window of the gun will be to launch in-bore packages of up to 500 grams at a velocity of approximately 2.8 - 3.0 km/s.

A gun pit was constructed to provide the capability to shoot a large caliber projectile into the target chamber.

(5) Loading Room. A loading room, located adjacent to the firing room, provides storage and support activities for handling powder gun propellants.

(6) Machine Shop. An onsite machine shop was constructed to provide R&D quantities of prototype penetrator and warhead designs. This facility includes a numerical controlled lathe, milling machine, a 500-ton press, and numerous other shop equipment. Engineering offices and a tool room are included in the facility layout.

(7) Material Laboratory. To conduct basic material research, the facility includes a material laboratory capable of mechanical testing and specimen preparation for optical examination. Material testing will include both low and high strain-rate behavior. High strain-rate material behavior will be evaluated from Hopkinson Bar and Taylor Impact tests. In addition to material testing, this facility will have the capability to process x-ray film.

(8) Administrative and Reception Area. The compound area can only be entered or exited through the Administrative and Reception Facility. Within this facility is office space for the site manager and nontechnical support staff. All personnel exiting the facility must be screened for hazardous material contamination. While inside the compound area, all personnel will wear protective clothing appropriate to their task involvement with hazardous material.

c. Personnel Safety and Environmental Aspects

The use of hazardous materials has prompted many concerns for the safety of personnel and the environment in and around the AWEF facility. The health hazard created by working with depleted uranium is primarily the risk of exposure to particle matter which can be inhaled or ingested. The facility design and operating instructions have been developed to minimize the risk of exposure.

Controlled access to the buildings at the AWEF provides the opportunity to monitor the use of protective equipment; i.e., protective garments, gloves, booties, air breathing device, etc. The personnel protection program was

developed on the basis of a four-level protection system. For example, personnel entering the target chamber will be protected at the highest level available. This protection includes a protective suit and breathing apparatus. When leaving a contaminated area of the compound all personnel will be screened for possible contamination. In addition, the various work areas, the machine shop, control room, etc., are routinely monitored to provide data on possible contamination.

From an environmental stand point, the facility site has been extensively studied since 1986. This study has provided information on the flora, the level of naturally occurring uranium, and the level of metal concentration existing in the soil. This baseline information will be used to monitor the environmental influence when the facility becomes fully operational. In addition to routine soil sampling, environmental monitoring will consist of ground water sampling, at 6 different locations, and air sampling at the perimeter of the compound. The exhaust system found in the design of each building incorporates detectors in the air filtration system to prevent airborne contamination from escaping.

Paramount during the development of the facility design and the operating instructions was the concern for minimizing the risk of exposing personnel and the environment to hazardous material contamination.

d. Future Goals.

The near term objectives are to initiate testing at the facility after completing the installation of equipment and facility checkout. Testing can begin after the completion of the first phase of the instrumentation contract and the awarding of a contract for operations and maintenance personnel. Long term objectives include a capability and performance study of the 60 millimeter powder gun, now under construction, and the development of warhead launch capabilities; i.e., test fixtures and target arrays.

The point of contact is Mr. Allen Welle, AFATL/MNW, Autovon 872-2141.

4. FUZES RESEARCH AND DESIGN LABORATORY

The Fuzes Research and Design Laboratory, located in Building 432, has been operational since 1976. Recently the Fuzes and Guns Branch, which is responsible for the Laboratory, was formed by combining the former Fuzes and Sensors Branch with the personnel from the Guns and Projectiles Branch.

The Laboratory is responsible for the development and evaluation of fuzes for conventional munitions. Facilities currently available include the following:

- a. Electronics Laboratory with printed circuit board production equipment.
- b. Shock and acceleration test equipment.
- c. Explosives bays.
- d. Ballistics test facilities.

e. Laser Test Laboratory.

f. Unique equipment for high "g" testing such as the smooth-bore 155-mm Howitzer gun and the 152-foot vacuum gun.

Conventional weapon fuzing spans a wide range of technology disciplines. Fuzing utilizes a range of sensor technology from a relatively simple crush of "g" devices to state-of-the-art acceleration, RF, electro-optical, infrared, magnetic, seismic, and acoustic sensors. Because fuzes must process extensive amounts of data in very short periods of time (usec to msec), and in extremely hostile environments, they present challenging data processing design requirements. Recent emphasis has focused on developing the sensor and signal processing necessary to do "smart" fuzing for hard target penetrating weapons. Significant progress has been made in the development of shock hardened sensors, signal processing circuitry, and shock hardened data recorders.

Another area of technology being exploited inhouse and on contract is the application of exploding foil initiators (EFI's), slapper detonators. Slapper detonators are electrical devices that produce direct shock detonation of secondary explosives with very precise timing. The elimination of primary explosives in the explosive cycle enhances handling and operational safety. The accurate super quick timing enables precise sequencing on multiple slappers which enhance warhead effectiveness.

Fuzes and fuze components are pretested at these facilities prior to full-scale sled testing and final evaluation in a warhead. This Laboratory also conducts extensive research, experimental development, advanced development and evaluation of seismic, acoustic, and magnetic sensors and associated signal processing circuitry for the detection, classification, ranging, and bearing determination of targets of interest. Future sensor development will exploit advances in fiber-optic magnetometers to extend detection range and improve target classification and bearing determination.

The point of contact is Mr. Nunzio Zummo, AFATL/MNF, Autovon 872-9431.

5. MECHANICAL MATERIALS DYNAMICS LABORATORY

The Mechanical Material Dynamics Laboratory (MMDL) was established to provide dynamic material properties. These properties are needed for continuum mechanics wave propagation computer codes (hydrocodes). The hydrocodes are used to predict fragment formation during warhead functioning and to support penetration research. This facility has been in operation since 1980.

This facility serves two main functions. First, it provides a quick response test capability to determine the dynamic mechanical properties of metals being used in warhead development programs. Secondly, it is used to establish constitutive relations of metals for hydrocodes. The facility can support metal fracture model development; however, it is not currently active in that area.



FIGURE 13. FUZES RESEARCH AND DESIGN LABORATORY

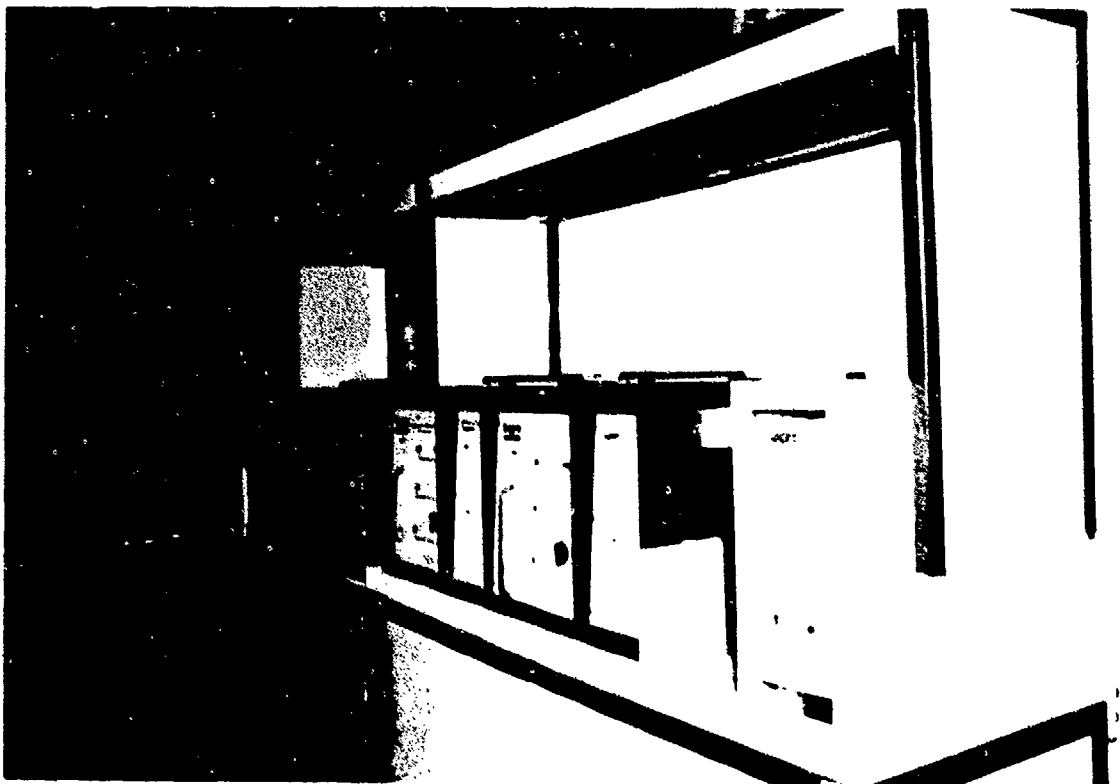


FIGURE 14. PRINTED CIRCUIT BOARD FABRICATION EQUIPMENT



FIGURE 15. SHOCK AND ACCELERATION TEST



FIGURE 16. 152-FOOT VACUUM GUN

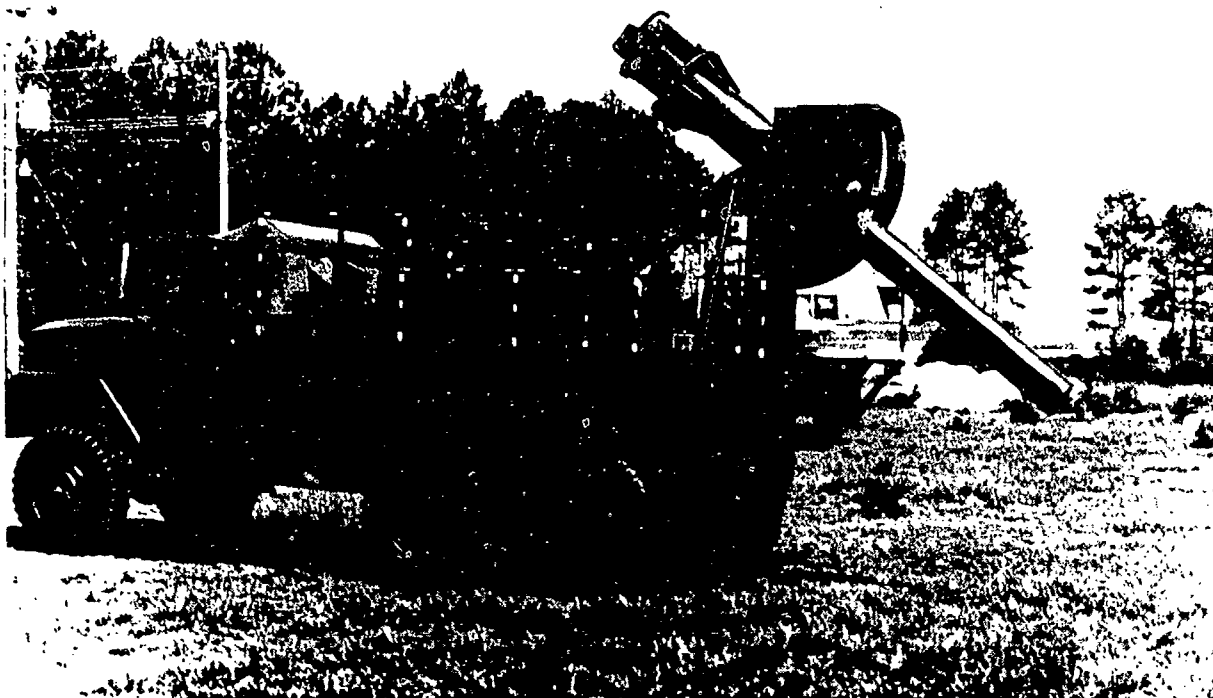


FIGURE 17. 155-MM HOWITZER FIRING VERTICALLY

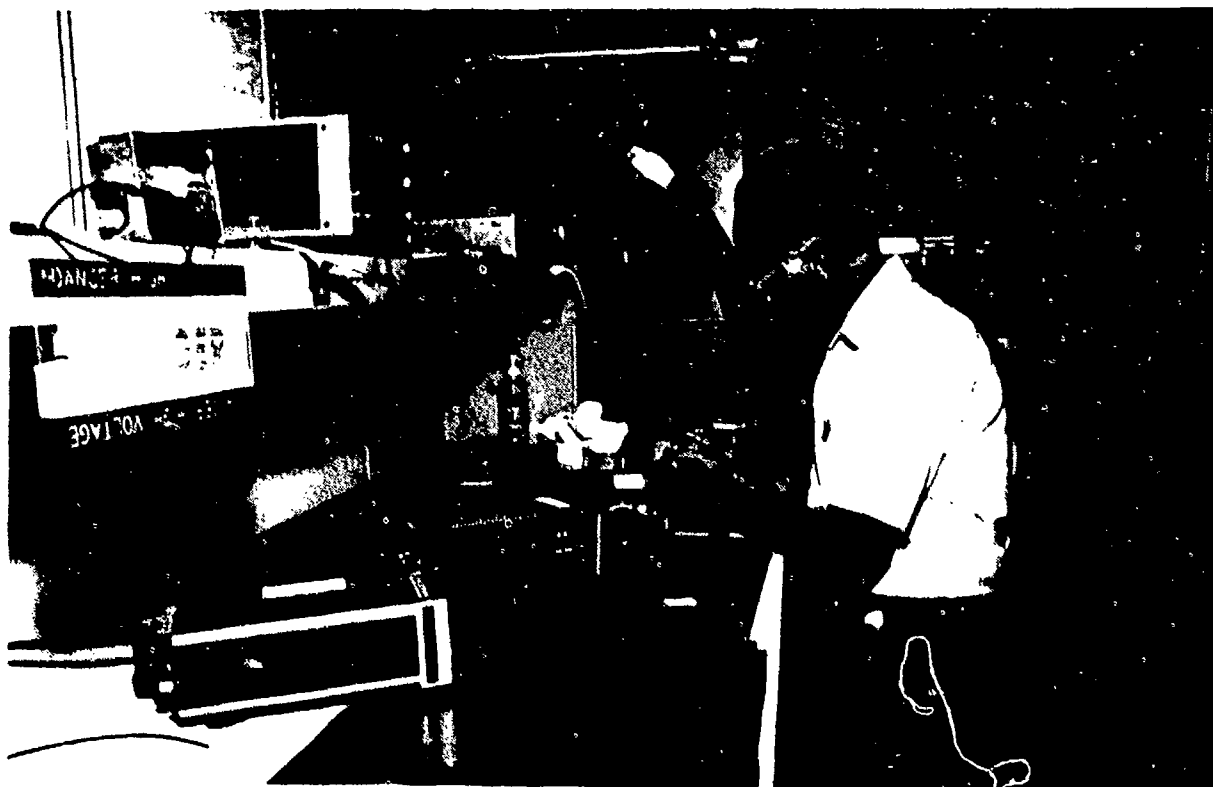


FIGURE 18 EXPERIMENTAL FUZE DEVELOPMENT

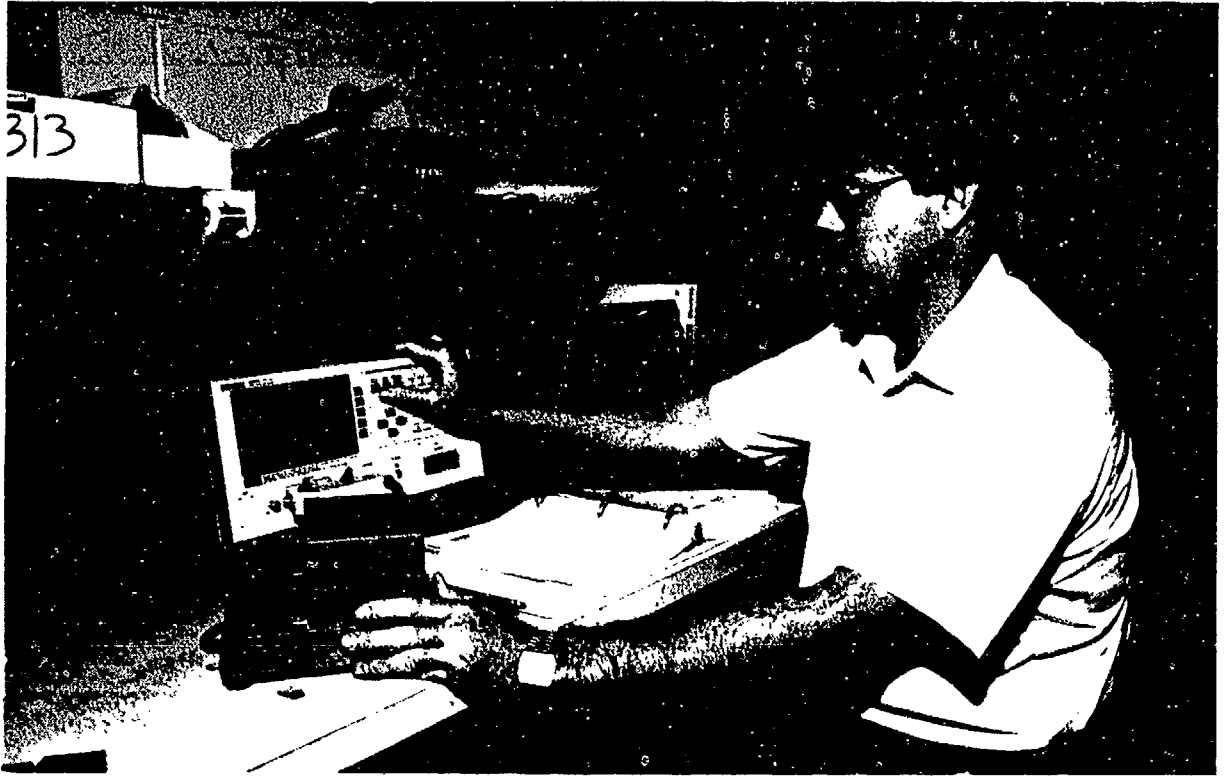


FIGURE 19. EXPERIMENTAL FUZE CIRCUIT TEST

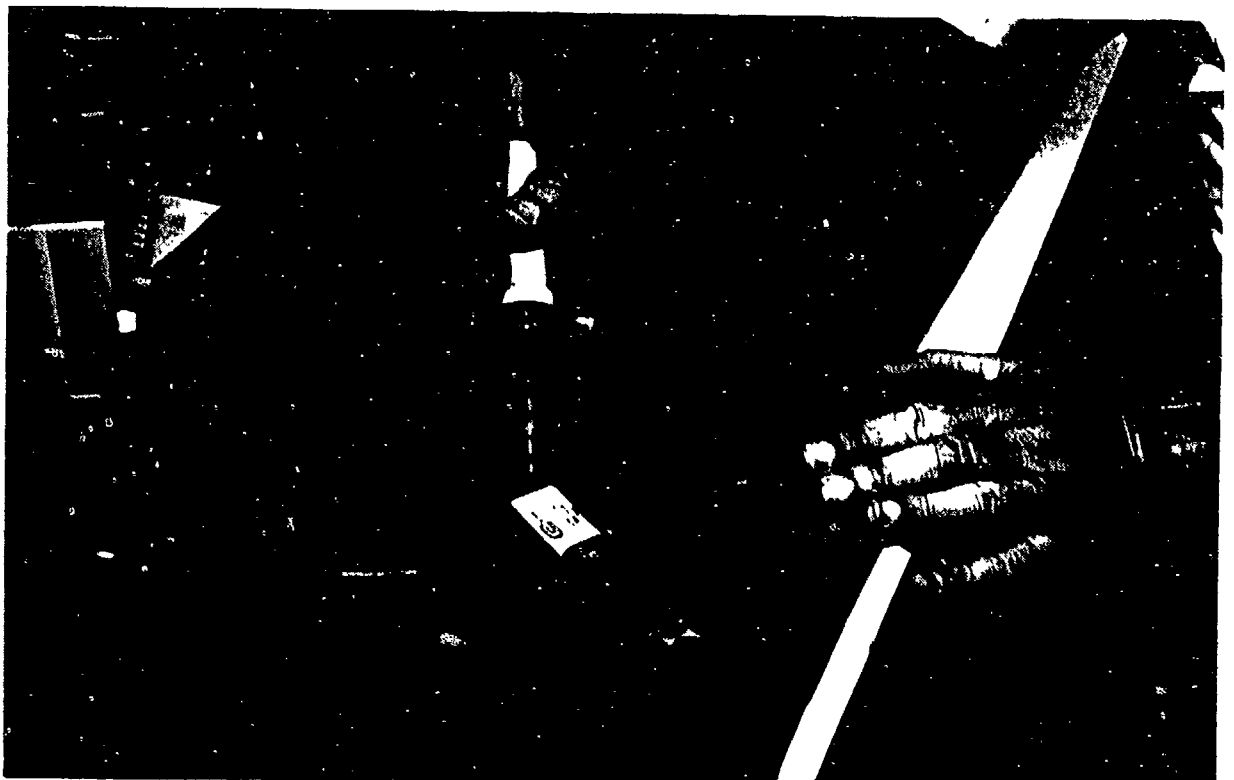


FIGURE 20. SLAPPER DETONATOR

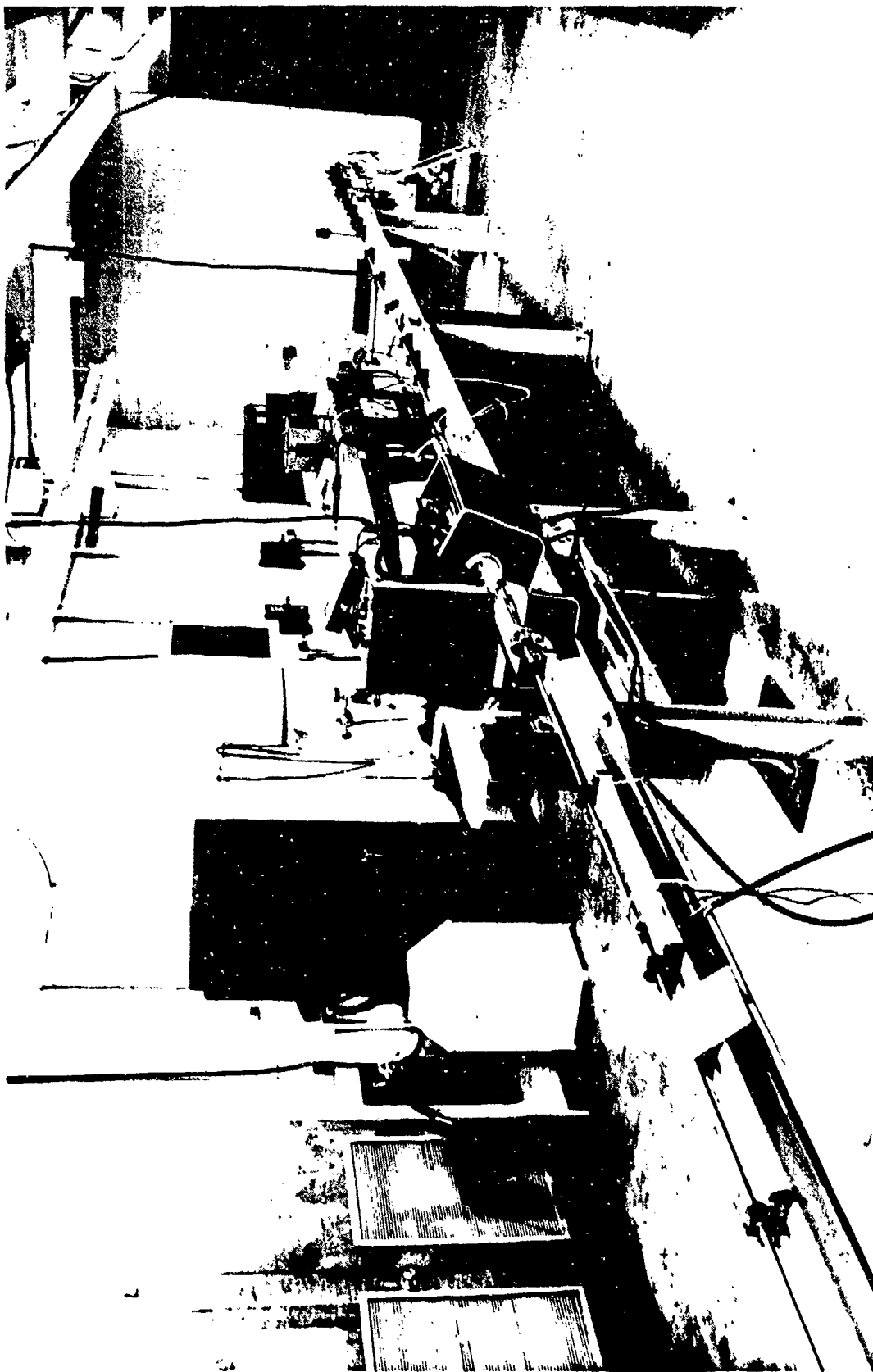


FIGURE 21. SPLIT HOPKINSON PRESSURE BAR

The MMDL has four functional areas. These include hydraulic material test systems, a split Hopkinson pressure bar, a self-contained 2-inch gas gun with environmental chamber, and metallography equipment. The capabilities have been selected to permit the mechanical characterization of metals from quasi-static strain rates to ultra-high strain rates and from room temperature to the highest practical temperatures.

A bi-axial servo hydraulic system with computer controlled loading capabilities is available for load path dependent plasticity research and measurements of anisotropic material response. A high rate Instron tensile tester provides tensile test capabilities for strain rates from quasi-static to 100 per second. At low strain rates a model 1332 load frame is configured for standard 0.505 round tensile specimens. This load frame is rated to 50,000 pounds and includes an environmental chamber capable of 2200°F inert atmosphere testing. At high strain rates a model 1321 load frame is configured for testing of the miniature round samples used in AFATL Hopkinson bar tests.

A split Hopkinson pressure bar provides a test capability for strain rates from 100 to 2000 per second. This device is capable of performing tests in both tensile and compressive modes and at temperatures from room temperature to 650 degrees C. It is unique in terms of its high temperature capability and the length of the system (42 feet). The long length allows tests at higher strains to be performed on this than on many others.

A 2-inch gas gun permits cylinder impact tests to be performed on metals, providing information on material strength at strain rates of roughly 10,000 to 500,000 per second. This system can test metals at temperatures of up to 2200 degrees F.

Metallographic capabilities, although limited, allow preparation of samples and examination of microstructures in most metals of interest to warhead development programs.

The MMDL is unique in the collection of techniques it offers for the investigation of high strain, high strain rate, high temperature material response for warhead development programs and penetration research. This laboratory interacts with the Computational Mechanics Laboratory where extensive hydrocode calculation capability exists. Hydrocode computations are essential for analysis of the highest strain rate tests.

The point of contact is Mr. Bill Cook, AFATL/MNW, Autovon 872-2145

6. COMPUTATIONAL MECHANICS LABORATORY

The Computational Mechanics Laboratory (CML) is responsible for the analytic support of warhead design engineers who need detailed physical understanding of processes such as the explosive formation of metals into kinetic energy penetrators or the prediction of armor penetration. The methodology is based on explicit finite element or finite difference schemes to solve the fundamental physical principals of conservation of mass, momentum, and energy. The primary computer programs suggested include the HULL and EPIC hydrocodes. HULL is primarily an Eulerian code, meaning that materials are tracked as they move through a laboratory reference frame. This type of code is best suited

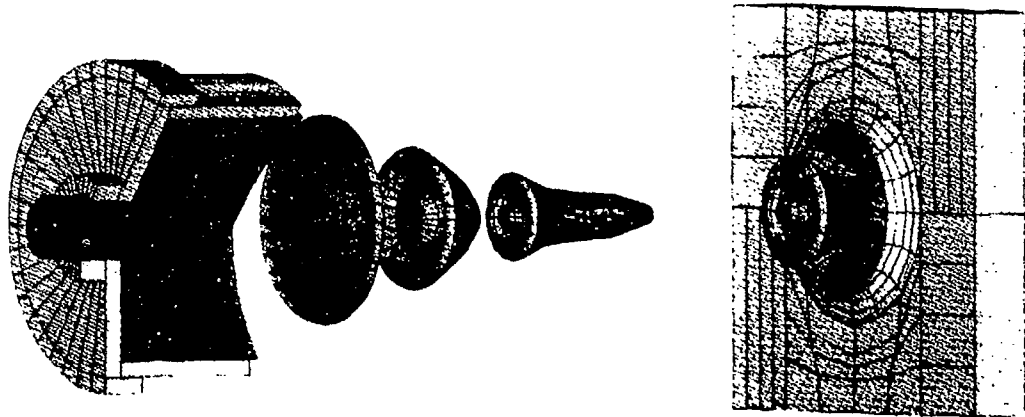


FIGURE 22. SIMULATION OF PENETRATOR AND TARGET IMPACT

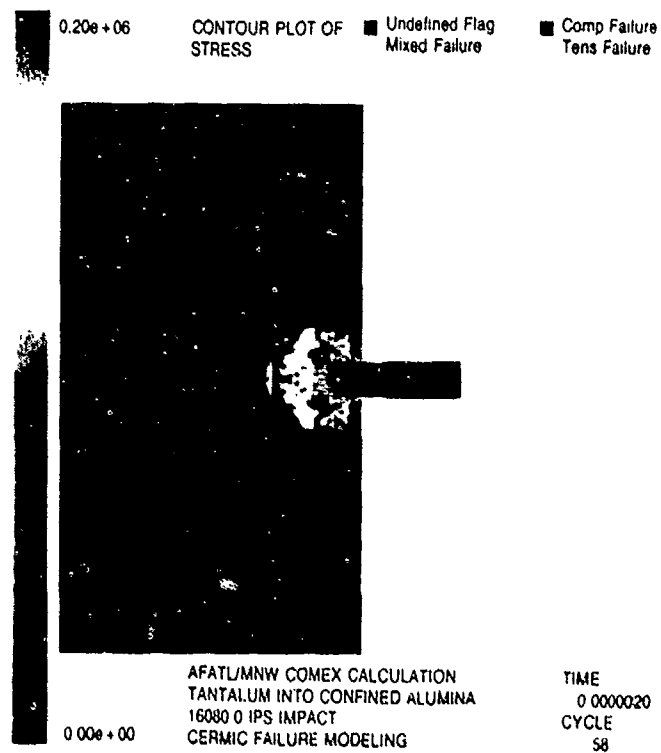


FIGURE 23. CONTOUR PLOT OF STRESS

to extremely dynamic processes with large material deformations. EPIC is exclusively a Lagrangian code, meaning that material deformations are monitored relative to an initial state through a reference grid system established in the material. This type of code is well suited to moderately large deformations, providing better tracking of the state of individual materials than Eulerian codes. Both codes are available for one, two, and three dimensional calculations. Both codes are wave propagation codes capable of tracking stress wave interactions critical to conventional weapon performance. Extensive efforts have been dedicated to accurately modeling material strength capabilities within these codes, and these models are constantly being improved and compared to test data obtained from the Mechanical Material Dynamics Laboratory (MMDL).

A typical hydrocode calculation with sufficient resolution to adequately resolve differences in the performance of typical warhead designs for explosively formed projectiles can require several hundred time iterations in a three-dimensional discretized space of 500,000 or more cells. Since a hydrocode is essentially solving 15 equations in 15 unknowns for each cell for each time step, the computational load is clear. Furthermore, interpretation of the results demands large computational resources to manipulate and display complex multidimensional results in a meaningful way. The CHL is a dedicated facility for the development of improved hydrocodes and for the interactive application of hydrocodes to warhead design problems. Large production calculations in two dimensions and most three dimensional calculations demand supercomputer resources. This facility provides powerful pre and post processing capabilities for those large problems, as well as the high speed gateway necessary to interact with national supercomputer centers.

Currently the CHL is using the following computer hardware:

- a. Multiflow Trace 14/200 minisupercomputer.
- b. DEC VAX 8650.
- c. Four DEC VAX station III/GPX workstations.
- d. Tektronic color graphics workstations including:
 - (1) Three 4207 low resolution color terminals.
 - (2) 4125 high resolution color video display.
 - (3) 4129 high resolution color video display with 3D solids capabilities.
 - (4) 4292 and 4293 color hardcopy devices.

Area of expansion in 1990 include:

- (a) Color workstation interface to video recorders for VHS videotape format presentation capability,
- (b) Enhanced interfaces to planned Eglin supercomputer.

The computer models developed by the CML are called hydrocodes. Hydrocodes are a highly complex set of mathematical equations and algorithms for simulating dynamic events. A typical practical application of hydrocodes is simulating penetration of a target by a warhead. This is accomplished by discretely breaking up the event. The penetrator and target are each approximated as being broken down into roughly thousands of discrete elements or cubes. Time is broken down into roughly 1,000 intervals so once the simulation is completed it may be played back (reviewed) in slow motion.

The mathematical models in the hydrocode account for conservation of mass, momentum and energy. Hydrocode strength and fracture models are computed as well. Hydrocode models involve 15 nonlinear differential equations. The computer model linearizes these to find a numerical solution to a given problem. These computations entail solving the 15 nonlinear equations for each element and time interval.

These models are constantly being improved and compared to test data developed in the Mechanical Materials Dynamics Laboratory (MMDL). The interaction between these two laboratories is beneficial in creating better warheads and more realistic models. The benefits of hydrocode simulations are the numerous scenarios which may be run and the tremendous time and cost savings over running actual penetration tests. Hydrocode simulations allow the simulation of events which could not otherwise be performed.

The amount of computations necessary to simulate a single penetration is enormous. While the current computer hardware accomplishes the task, it is fairly slow and less detailed. Some of the more complex mathematical models the CML is trying to develop are constrained by the current hardware. However, in fiscal year 1990/1991 MSD is installing a super computer. Once installed, the CML will use their current computers to set up a penetration scenario and transfer the information to the super computer, where it will be solved much faster. This addition will greatly enhance the capabilities of the CML.

The point of contact is Mr. Bill Cook, AFATL/MNW, Autovon 872-2145.

SECTION IV AEROMECHANICS DIVISION

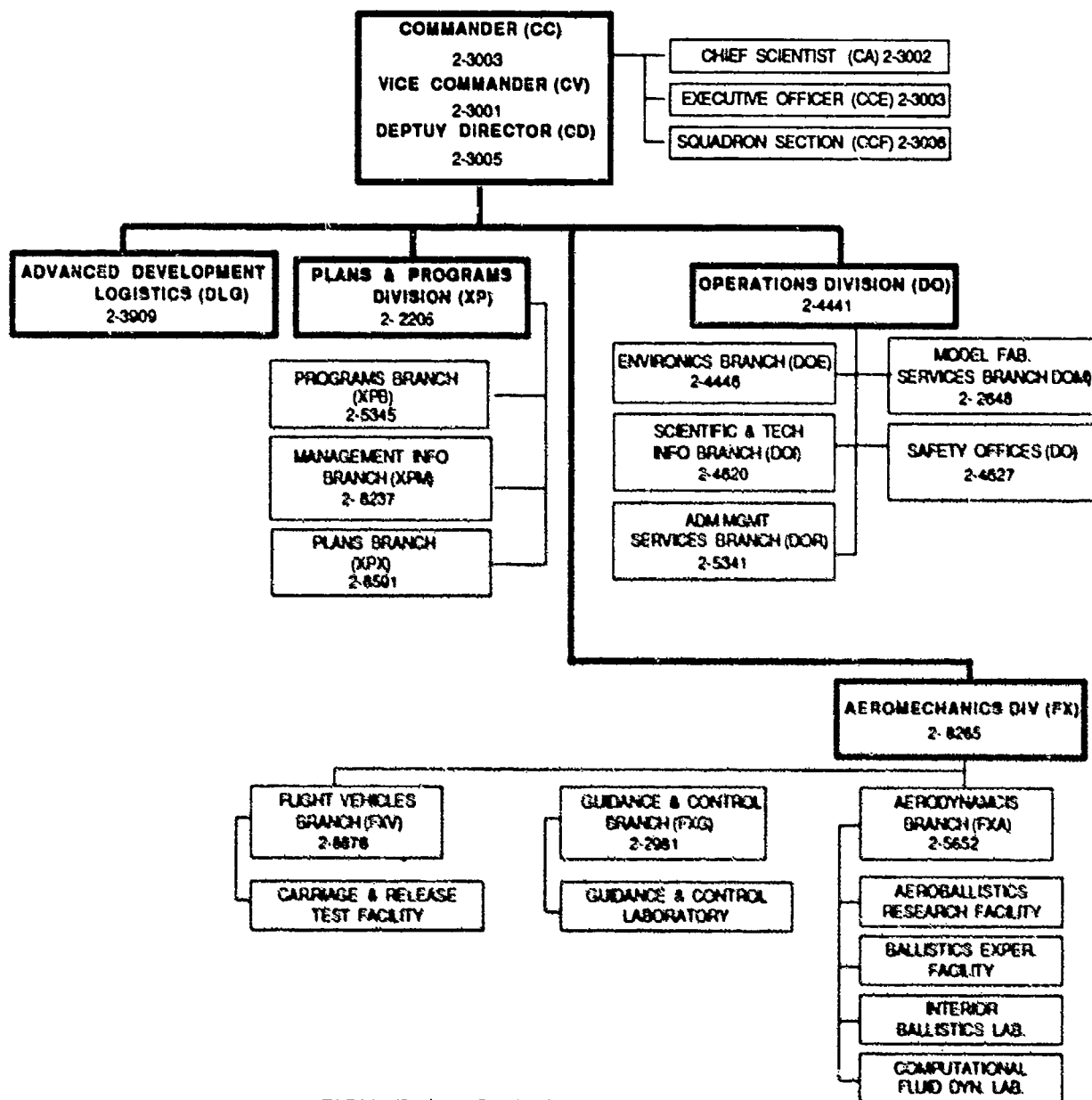


FIGURE 24. ORGANIZATIONAL CHART

1. MISSION OVERVIEW

The Aeromechanics Division (FX) directs and conducts basic research, exploratory development, and advanced development of weapon / missile airframes and weapon carriage and release equipment; develops and demonstrates aerodynamic and structural technologies that support weapon / missile airframe programs and system integration for present and future aircraft; investigates and develops guidance and control system technologies; and operates the Aeroballistic Research Facility (ARF), the Ballistics Experimentation Facility (BEF), the Interior Ballistics Laboratory, the Guidance and Control Laboratory, the Carriage and Release Test Facility, and the Computational Fluid Dynamics Laboratory.

2. FREE-FLIGHT TEST FACILITIES

The Aeromechanics Free-Flight Test Facilities, consisting of: the Aeroballistics Research Facility, the Ballistics Experimentation Facility, associated model/launcher design capabilities and data reduction and analysis systems; and launcher systems evaluation and instrumentation systems development capabilities. The facilities provide an integrated launch and flight technology development tool to support a wide range of munition program requirements. Combined with the capabilities of the Interior Ballistics Laboratory, a broadly based launcher and flight systems test capability is available to support technology development requirements in several areas:

- a. Gun system design and advanced propellant evaluation.
- b. Projectile in-bore acceleration and transition to free flight.
- c. Free-flight studies involving
 - (1) Static and dynamic aerodynamic parameter measurement,
 - (2) Flowfield visualization and characterization,
 - (3) Telemetry systems development,
 - (4) Free-flight signature and flowfield/radiation interaction,
 - (5) Acceleration-hardened onboard electronics and data recording instrumentation.

The Free-Flight Test Facilities complex provides a combination of both indoor, controlled environment, and outdoor ranges with interchangeable launcher and recording/diagnostic instrumentation systems capabilities. Flexible response and cost effectiveness are maintained by utilization of long range resources most pertinent to the test requirements. Concurrent operation of individual range facilities permits simultaneous, low-risk development of new model and launcher designs while acquiring data from production testing in other test units.

Historically, one of the applications of free-flight testing has been the measurement of aerodynamic forces and moments experienced by both full scale and sub-scale missile, ordnance, and aircraft configurations. Both subsonic and supersonic interference-free motion of launched models responding realistically to in-flight static and dynamic loads yields information concerning the stability characteristics of flight configurations often not available from fixed model test facilities. In addition, visualization of boundary layer transition, wake flowfield structure, flowfield interaction phenomena, and flow separation behavior afforded by a variety of sensitive optical instrumentation can provide valuable design and performance evaluation data. Combined gun system diagnostic instrumentation and projectile launch performance visualization via optical and x-ray shadowgraphy and laser illuminated photography provides an extremely valuable capability for evaluating candidate gun system designs and proposed model designs for utilization within the Aeromechanics Division test facilities and at other field applications.

a. Facility Descriptions.

The Aeroballistics Research Facility (ARF) is an enclosed, instrumented, concrete structure designed for studying the free-flight characteristics of projectiles and missile configurations. The structure houses a launcher room, blast chamber, instrumented range, model measurements room, and the facility operations room (Figure 25). The 207-meter instrumented length of the range has a 3.66 meter square cross section for the first 69 meters and a 4.88 meter square cross section for the remaining length. There are 131 locations, having a nominal physical separation of 1.52 meters, available as instrumentation sites accessible via an instrumentation corridor along the range. The facility is an atmospheric test range in which the environment is controlled to 22 ± 1 degrees Centigrade and less than 50 percent relative humidity.

The Ballistics Experimentation Facility (BEF) is a 0.25 by 1.5 mile outdoor test range having a capability for the mounting of a wide variety of specialized launchers and target structures. The BEF is typically utilized for initial development and launch/flight verification of non-standard launch techniques and models scheduled for test support in the ARF. In addition, the BEF is utilized for studies of munition free-flight and impact phenomena relative to stability and/or terminal impact effectiveness. The facility has the capabilities for determining model position, velocity, orientation, spin rate, and penetration characteristics.

b. Model Configurations.

Figure 26 illustrates some of the configurations tested to date. Both fullscale and subscale configurations can be flown, depending upon fullscale size and flight velocity. Both axisymmetric and asymmetric configurations, including spin stabilized and nonspinning models, have been flown. Certain configurations require sabots for launch support (Figure 27). The sabot components are separated aerodynamically after muzzle exit and trapped within the range blast chamber. Typical test results have included the determination of the following:

(1) Subsonic and transonic aerodynamics of wraparound fin configurations.

(2) Transonic aerodynamic effects of probe induced flow separation on bluff body flowfields and model drag.

(3) Aerodynamic stability characteristics of high length-to-diameter ratio missile configurations having either fin or flare stabilization.

(4) Subsonic and transonic aerodynamics of a generic fighter configuration and a complex asymmetric missile.

(5) Relative trajectory and aerodynamics of a dispenser and aft-ejected subpack.

(6) Subsonic through supersonic aerodynamics of numerous spin stabilized projectile configurations.

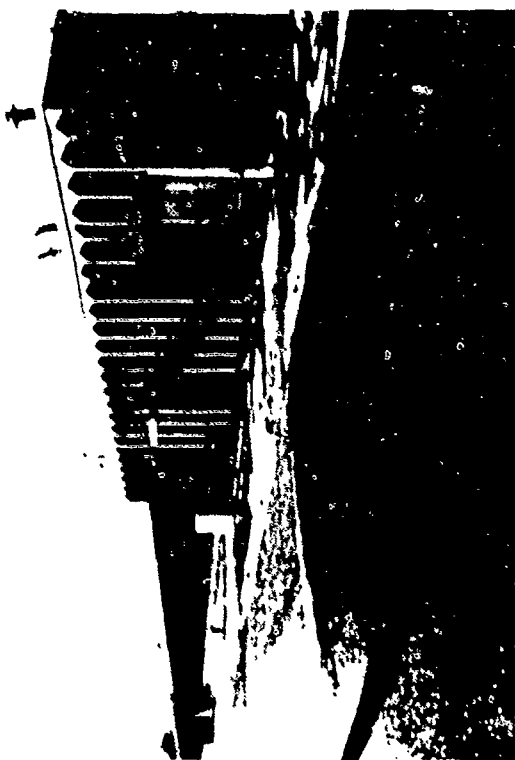
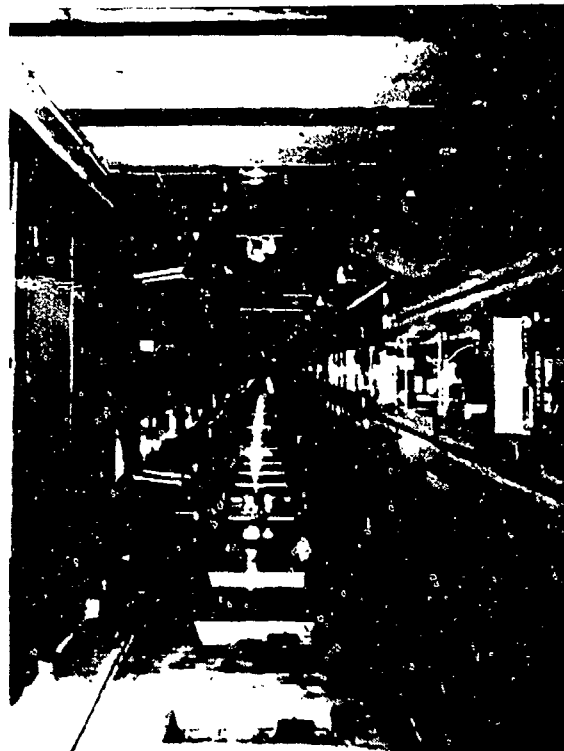


FIGURE 25. AEROBALLISTIC RESEARCH FACILITY

(CLOCKWISE FROM UPPER LEFT: RANGE INSTRUMENTATION, RANGE INTERIOR, OUTSIDE VIEW, DATA DIAGNOSTIC CENTER)

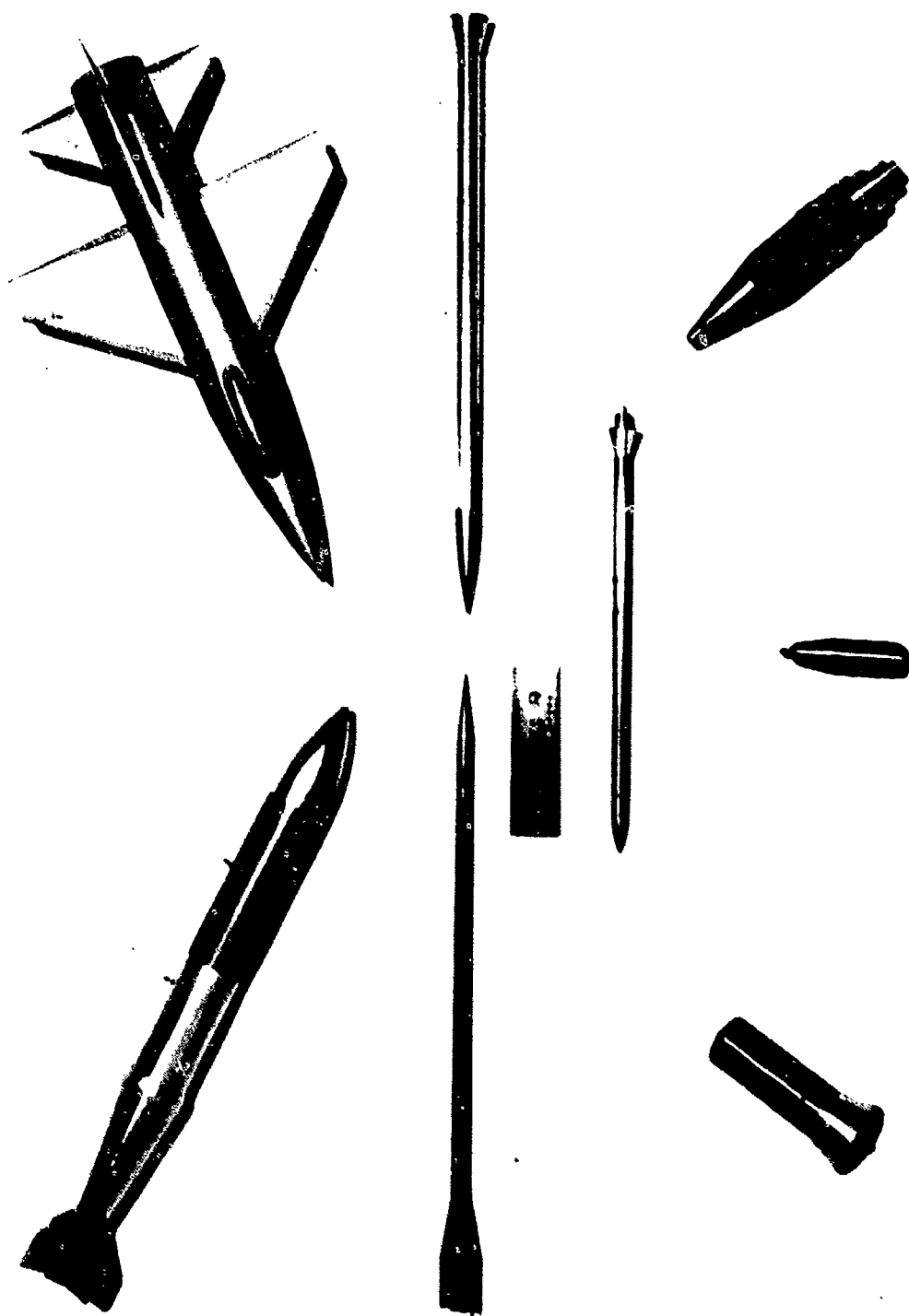


FIGURE 26. TYPICAL MODELS AND PROJECTILES

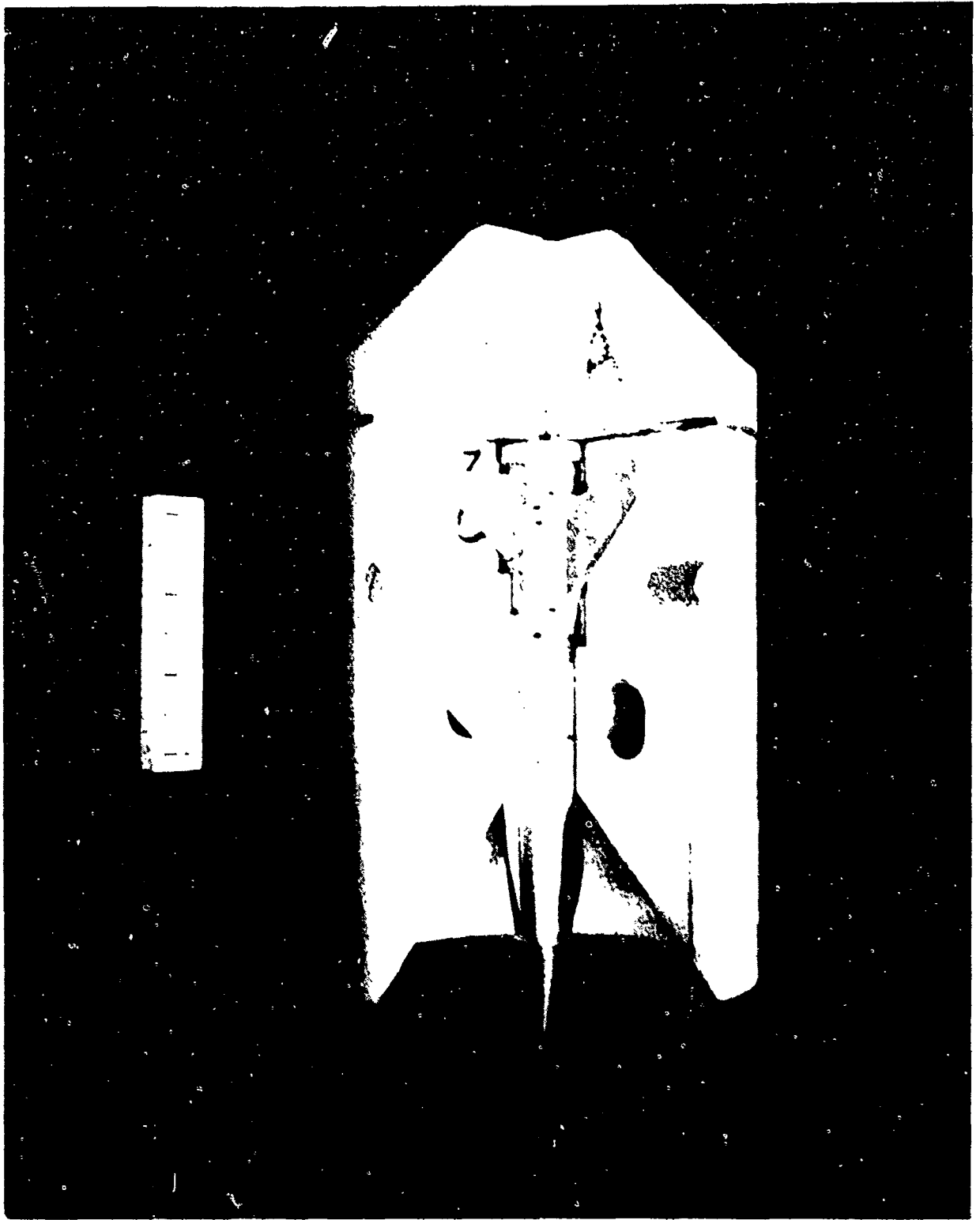


FIGURE 27. MODEL-SABOT PACKAGE FOR GENERIC FLIGHT CONFIGURATION

Fullscale configurations are often tested to demonstrate actual dispersion, roll history, and flow field details of interest in addition to measurement of conventional aerodynamic parameters.

c. Launch Capability.

A number of launchers are available, including powder guns, compressed gas launchers and a two-stage light gas gun. Launchers presently available for use are listed in Table 1. In addition, special purpose and development launchers also can be adapted readily to the available mounting system. Launch velocities obtainable are a function of a number of factors, including the following:

- (1) Type of launcher.
- (2) Total in-gun mass (model and sabot).
- (3) Launcher charge (powder type and mass, gas charge pressure, etc.).
- (4) Launch cycle implementation.

Tests have been conducted at subsonic, transonic, supersonic, and hypersonic Mach numbers (up to Mach 10). Generally, larger total in-gun mass results in lower muzzle exit velocities. Likewise, increased launcher charge results in greater in-bore acceleration and muzzle velocity. Inertial loading during in-bore acceleration is a design factor for more complex and fragile models. Increased launcher length for a given muzzle velocity and total mass generally results in reduced peak in-gun acceleration and inertial loading.

TABLE 1. AVAILABLE LAUNCHER

A. POWDER GUNS

Bore Diameter (mm)	Range of Barrel Lengths (m)	Available Twist Rates (deg/cm)
20	1.2 - 1.5	Smooth 4.83 5.15 7.09 11.07 Various Gain Twists
25	2.13	4.76 6.56
30	1.3 - 2.6	Smooth 2.95 5.90 6.04 7.09 7.87 8.86 11.81
40	2.4 - 3.0	Smooth 7.10
76.2	9.2	Smooth

B. COMPRESSED-GAS LAUNCHERS

Bore Diameter (mm)	Range of Barrel Lengths (m)	Available Twist Rates (deg/cm)
152.4	3.7, 4.8	Smooth
* 203.2	4.8	Smooth
* 355.6	4.3	Smooth

C. LIGHT-GAS GUN

Bore Diameter (mm)	Range of Barrel Lengths (m)	Available Twist Rates (deg/cm)
20	3.0	Smooth
30	3.0	Smooth
40	3.0	Smooth

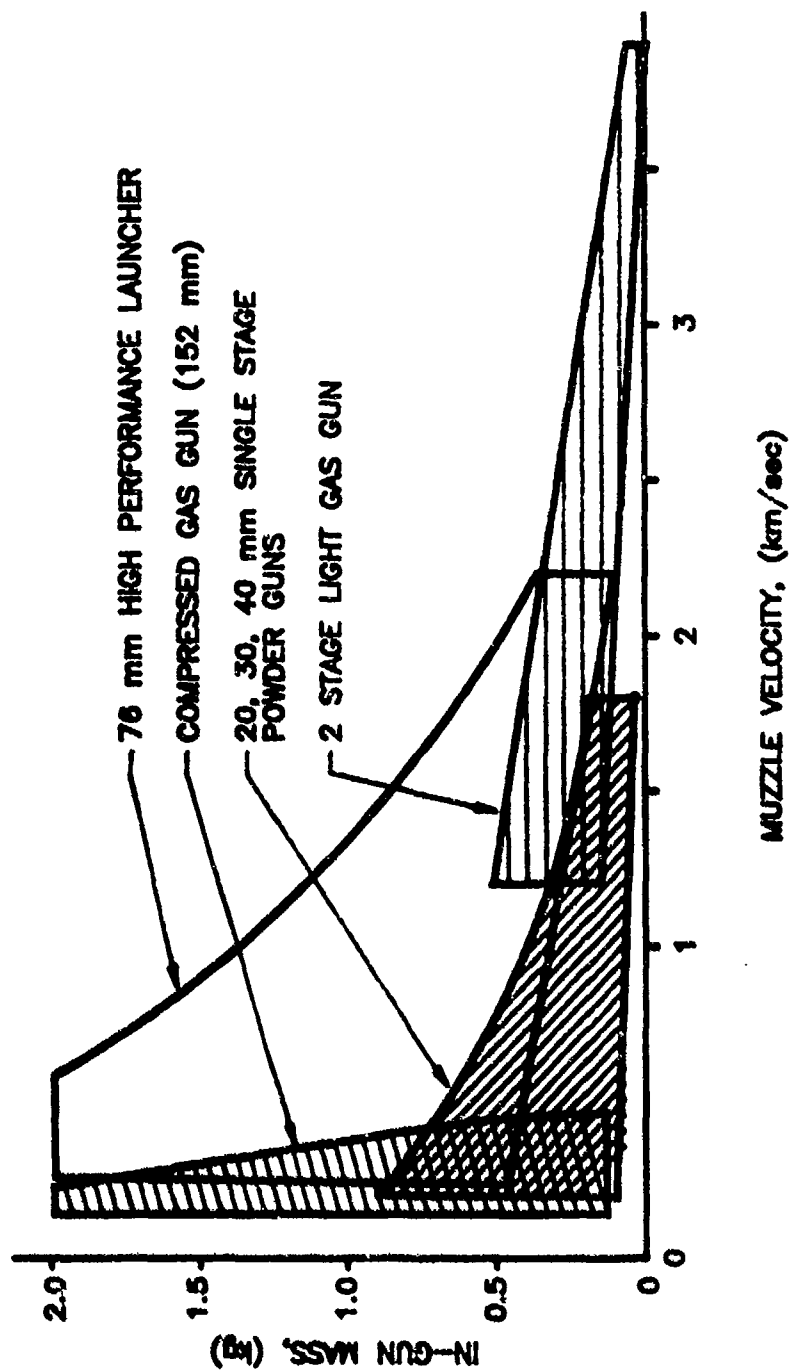


FIGURE 28. LAUNCH CAPABILITY FOR AVAILABLE GUN SYSTEMS

Figure 28 illustrates the velocity versus in-gun mass capability of representative available launchers. The test facility has a continuing program for developing and obtaining improved launch capabilities, including:

- (1) launching larger and heavier models at currently achievable velocities,
- (2) increased launch velocities for current launch masses,
- (3) decreased peak in-bore acceleration for relatively delicate model design packages.

For example, the 76.2mm bore single-stage High Performance Launcher (Table 1) was acquired to give a capability to launch 1.0 kg packages at maximum muzzle velocities of up to 1.7 km/sec and relatively delicate packages in the 1.0 km/sec velocity range. The 76.2mm High Performance Launcher is a primary component of the two-stage light-gas gun listed in Table 1. This gun system can launch 30-mm diameter packages at velocities near 4.0 km/sec.

In the Ballistics Experimentation Facility, three different compressed gas guns are available to provide launch capabilities for weights up to 45 kg and velocities up to 610 m/sec. For tests requiring higher velocities than those achievable with the compressed gas guns, several smooth-bore powder guns are available.

d. Instrumentation and Data Acquisition

Optical instrumentation systems are available to acquire free-flight model position-attitude-time histories for flight dynamics studies, to define flow field structure to support fluid dynamics analysis and configuration design studies to provide high quality model surface definition photographs for launch-induced damage and survivability studies. A dual-plane reflective-screen spark shadowgraph system is available for inflight imaging of model silhouette and density gradients present in the surrounding flowfield. The 207-meter length of the ARF presently has 55 orthogonal shadowgraph stations. Figure 29 shows a shadowgram of a supersonic projectile in flight.

Spark source duration is less than 0.3 microseconds, measured at the half-intensity of the peak light output. This maximum spark duration results in a motion blur of less than 1.4 mm at 4.6 km/sec (Mach 13) and less than 0.2 mm at 0.69 km/sec (Mach 2). The shadowgram system produces high contrast both in the model silhouette, which is required for high quality angle-and-position-reading accuracy. The flowfield features (e.g., shock structure, wake details, and boundary layer growth) are made visible as a result of variations in gas density which result in variations in the refractive index (Figure 30).

Five of the 55 shadowgraph stations are configured as four-image multispark stations, designed to provide closely spaced shadowgrams, useful for models having very high nutational angular motion rates (Figure 31). Nominal model displacement between images is 0.61 meter for these multispark stations.

The ARF has one 20 nanosecond pulsed laser photographic station located in the uprange end of the instrumented section. This system provides four

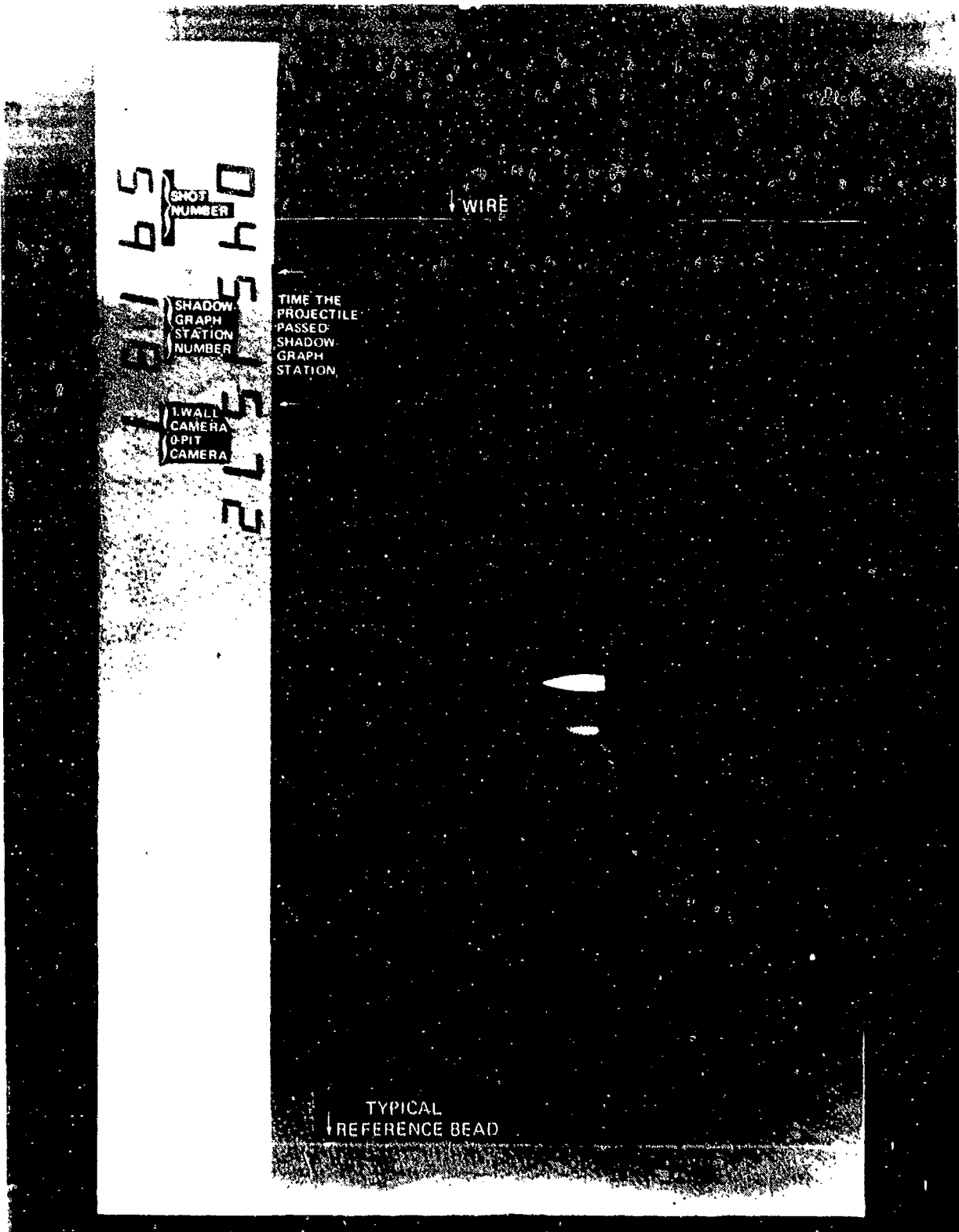


FIGURE 29. TYPICAL SHADOWGRAM

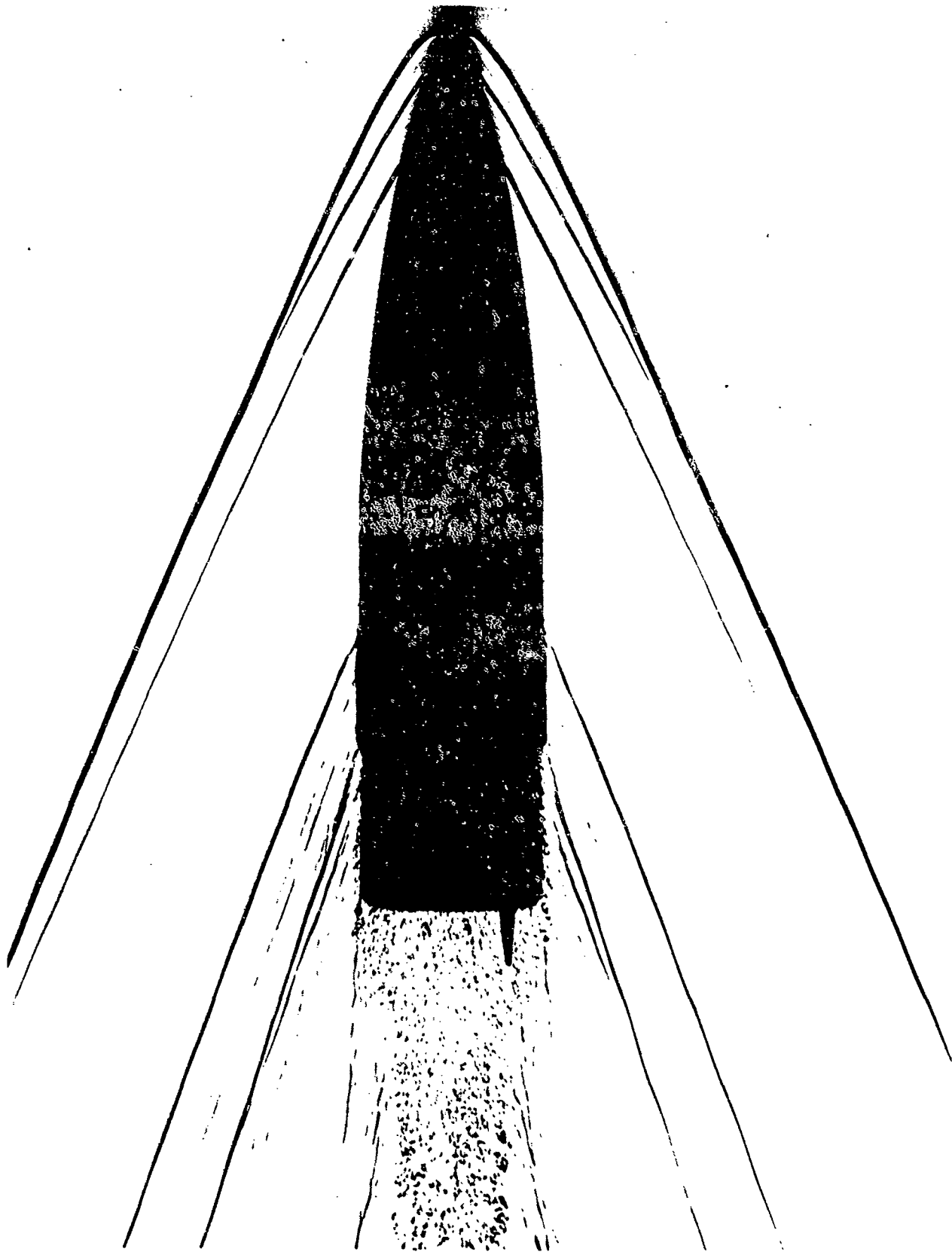


FIGURE 30. FLOWFIELD FEATURES DEFINED BY SHADOWGRAM FOR SUPER-SONIC FLIGHT CONDITION

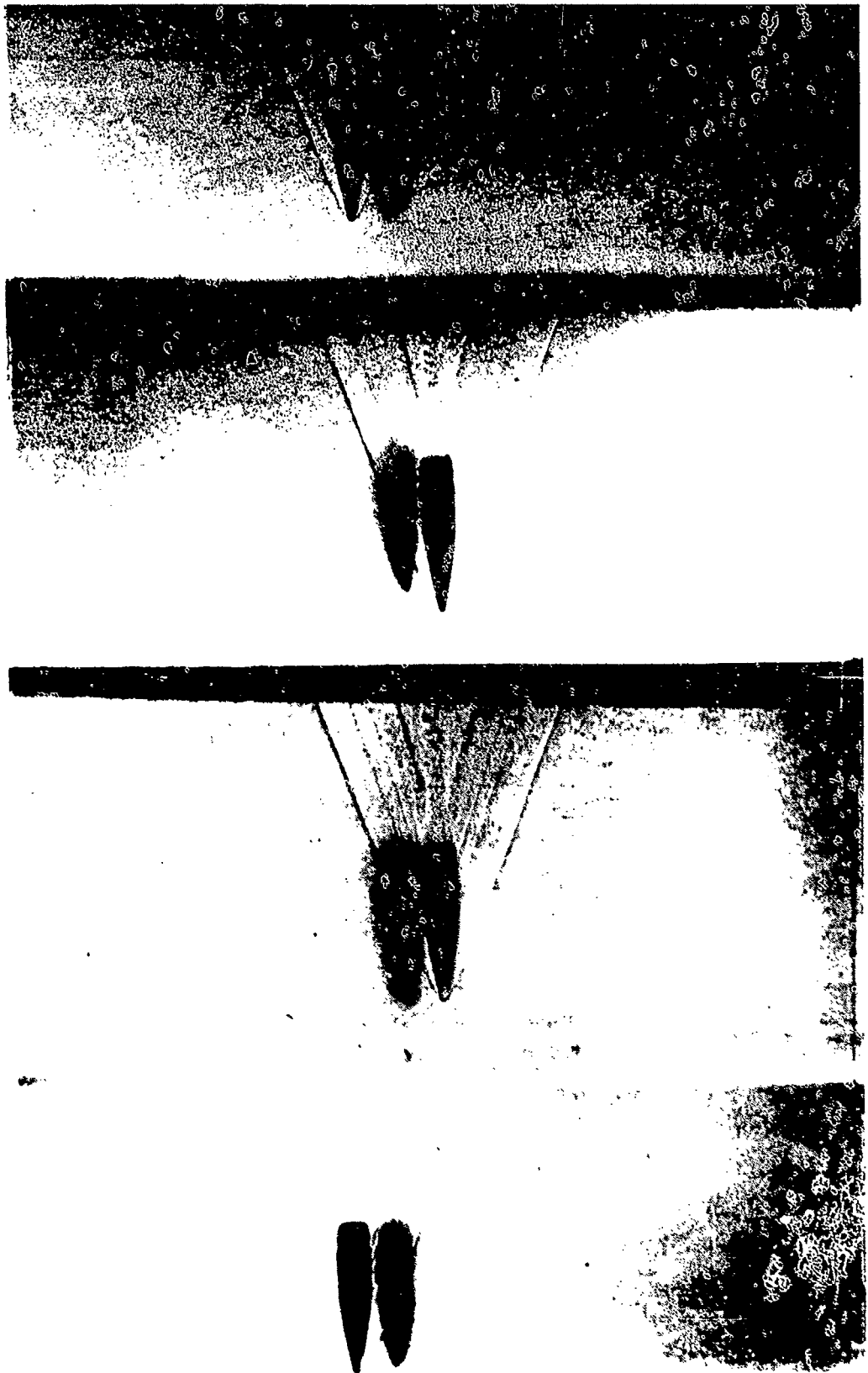


FIGURE 31. TYPICAL MULTIPLE SPARK SHADOWGRAM

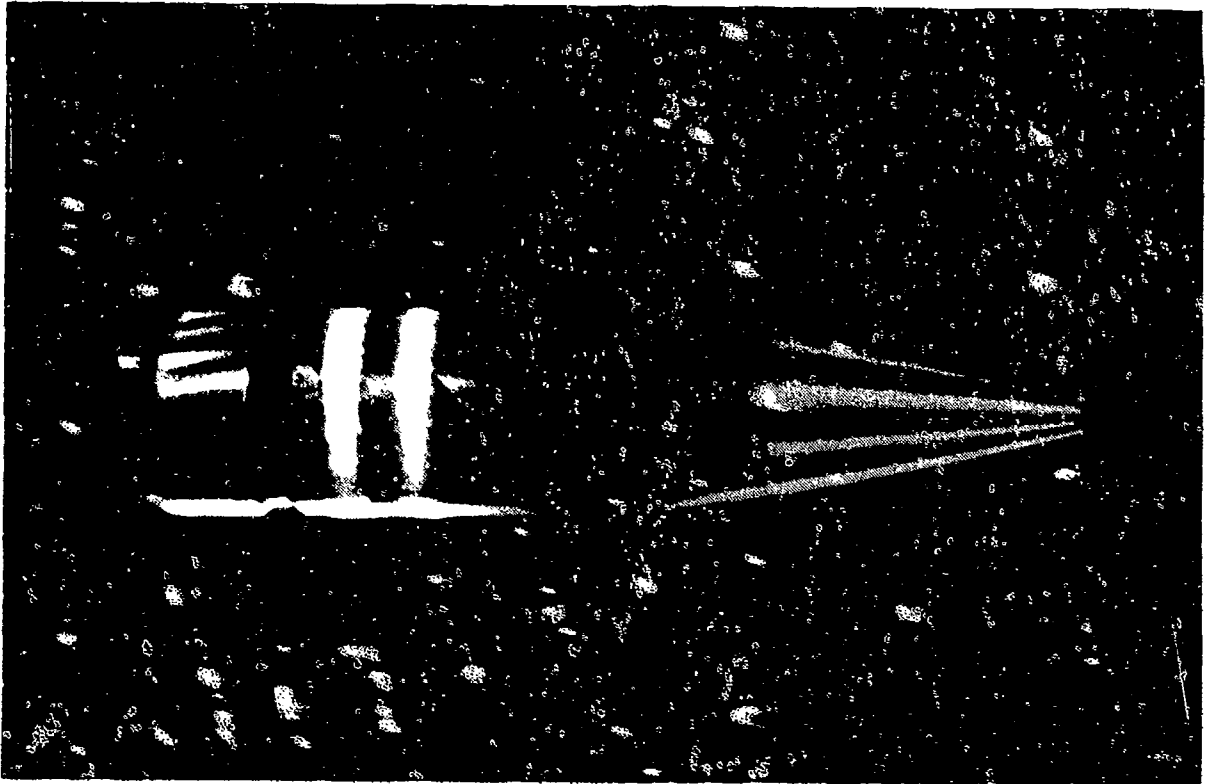


FIGURE 32. TYPICAL LASER LIGHTED PHOTOGRAPH (30MM PROJECTILE)

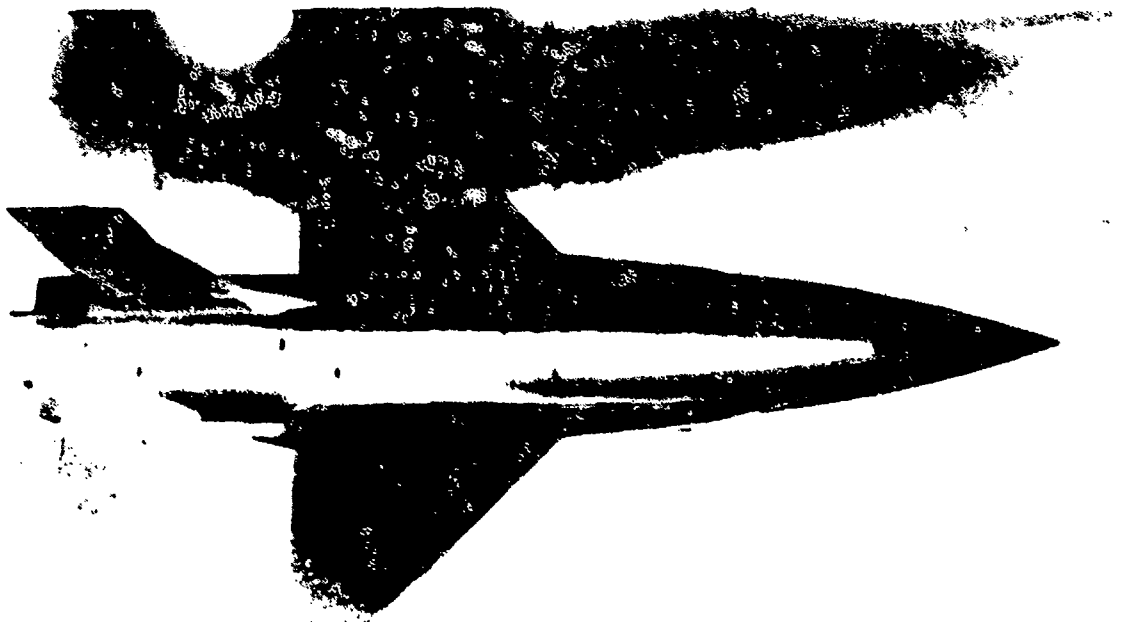


FIGURE 33. TYPICAL LASER LIGHTED PHOTOGRAPH (AIRCRAFT CONFIGURATION)

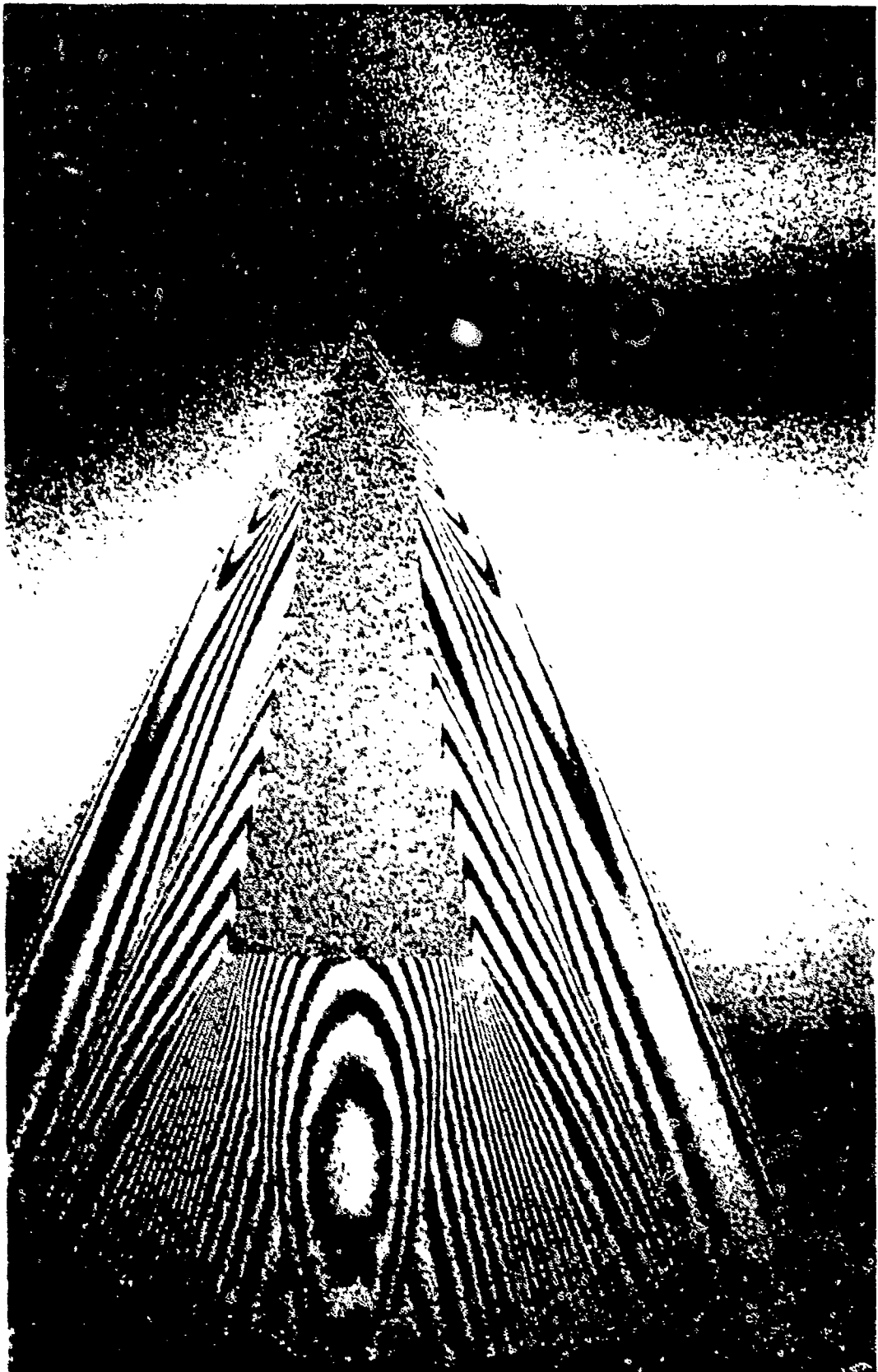


FIGURE 34. LASER HOLOGRAPHIC INTERFEROGRAM

simultaneous orthogonal photographs, yielding a complete 360-degree view of the model in flight. The extremely short pulse produces very sharp photographic images (motion blur is less than 0.1 mm at 4.6 km/sec), and as a result of the narrow spectral range of the light source, spectral filtering at the camera can produce essentially complete rejection of unwanted light, e.g., from thrusting model combustion product luminosity and from muzzle flash. Typical laser lighted photographs are shown in Figures 32 and 33.

A laser holographic station has been developed to provide interferometric data to permit defining the density field surrounding a model in flight (Figure 34).

A second developmental shadowgraph system, based on CCD technology, has been installed for evaluation in the ARF. The system, referred to as an electronic shadowgraph, is designed to replace the film camera system currently in use. This experimental system will be capable of resolving the model's position and attitude to the same precision as the existing film system. The resulting digital data can then be processed, displayed, and analyzed almost instantaneously, thereby eliminating the film handling, developing, and reading processes now in use.

Launch worthiness and sabot separation dynamics evaluations can be conducted economically and at low facility risk within the BEF. A pulsed x-ray shadowgraph system is available to provide either flight sequential or orthogonal exposures which are unaffected by intense muzzle flash, model self-luminosity, or smoke. Likewise, terminal ballistics evaluations of pre-impact projectile attitude and orientation and post-impact target/projectile response and deformation can be imaged utilizing the pulsed x-ray system. However, flow field visualization is not available with this system.

A CW microwave radar system is available to provide continuous velocity measurements directly from the determination of the Doppler frequency from near head-on microwave beam reflection. Continuous records can be obtained over relatively extended periods of a flight trajectory.

In addition, conventional high speed motion picture camera systems are available for providing photographic data at up to 400 frames per second.

e. Data Reduction and Analysis Techniques.

Aerodynamic flight dynamics data are derived from measured time, linear position, and attitude histories. A number of techniques exist for determining the aerodynamic characteristics of models in free flight. Usually, the governing differential equations of motion are integrated, either analytically or numerically, in an iterative manner with different values of the aerodynamic parameters to be determined and trajectory initial conditions until a best fit to the measured trajectory position and attitude data is achieved. The resulting fit accuracy can usually be made equivalent to the data measurement capability of the range when the aerodynamic model is functionally adequate. Both linear and nonlinear aerodynamic force and moment parameters can be derived via this technique. In general, the aerodynamic forces and moments are described as nonlinear functions of the angle of attack, Mach number, and aerodynamic roll angle. Accurate measurement of an individual aerodynamic parameter of interest is possible if the observed free-flight motion is significantly influenced by that individual parameter.

The data analysis system currently in use for deriving aerodynamic parameters from trajectory data in the ARF is illustrated in Figure 35. This system is referred to as the Aeroballistic Research Facility Data Analysis System (ARFDAS). ARFDAS incorporates both a standard linear aerodynamics data analysis method and a full six-degree-of-freedom (6-DOF) numerical integration method. The 6-DOF technique utilizes a Maximum Likelihood Method (MLM) to implement the best-fit parameter search methodology. Further, ARFDAS provides a capability to analyze both axially symmetric and asymmetric models.

The essential steps of the data reduction systems are to: assemble the flight data including time, position, attitude data, model physical properties, and range atmosphere test conditions, complete a linear aerodynamics data analysis; and, complete a 6-DOF numerical integration analysis for final aerodynamic parameter determination. These steps are integrated into the ARFDAS to provide a convenient and efficient means for interactive data analysis. Figure 36 illustrates angular motion data and 6-DOF integration results for three flights in the ARF.

Each model trajectory is analyzed separately; however, up to five flights of identical configurations can be grouped for simultaneous analysis using a multiple-fit capability to derive a common set of aeromechanic parameters. This multiple-fit approach provides a more complete range of angle of attack and roll orientation than may be available from a single flight and increases the confidence associated with the final parameter set.

Several coordinate systems are involved in the data reduction and analysis process. Each system has certain attributes which are more useful in specific applications, and often data reduction can be most successfully completed in one or the other coordinate systems. At present, three separate 6-DOF packages are available in the ARFDAS to take advantage of coordinate system differences; namely, the following:

- (1) MLMFXPL - a fixed-plane 6-DOF analysis method for inertially symmetric configurations having possible body-fixed aerodynamic asymmetries and high roll rates.
- (2) MLMBDFX - a body-fixed 6-DOF analysis method for inertially asymmetric configurations or symmetric configurations having low roll rates.
- (3) MLMBALL - a fixed-plane 6 DOF analysis method for symmetric configurations having moving internal parts.

Flexibility in choosing the most appropriate aerodynamic model is allowed in the selection of aerodynamic coefficients to be determined from the flight records.

The aerodynamic forces and moments acting on a body in free flight are the result of the flow field induced pressure distribution on the shape. The flow field is influenced by many variables, including configuration, flight conditions, and instantaneous flight attitudes. An aerodynamic model describing the dependence of the nondimensional forces and moment coefficients on various flight states is selected initially, depending on previous data or theoretical predictions. The aerodynamic coefficients can be assumed to be nonlinear functions of the total angle of attack and possibly the aerodynamic

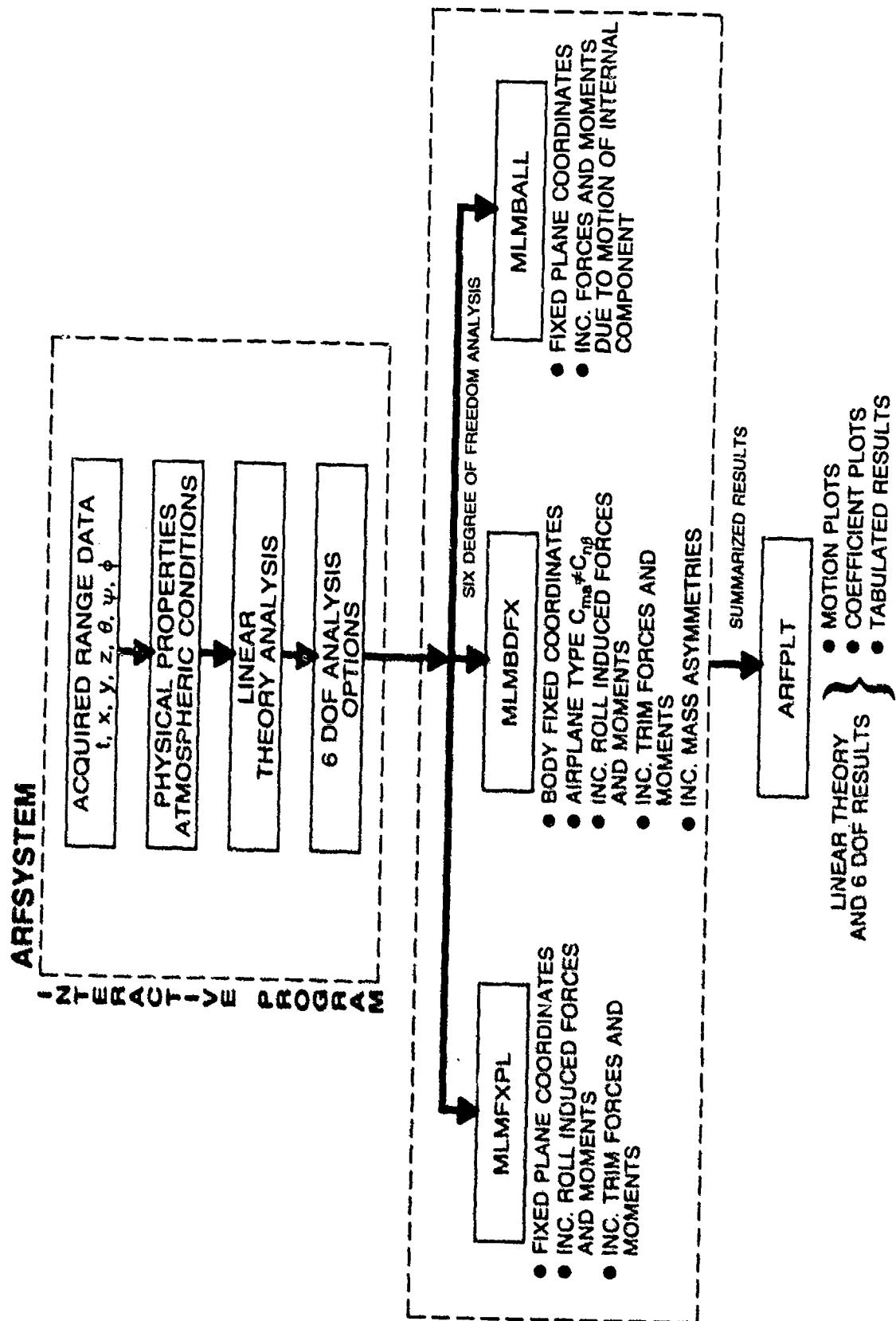
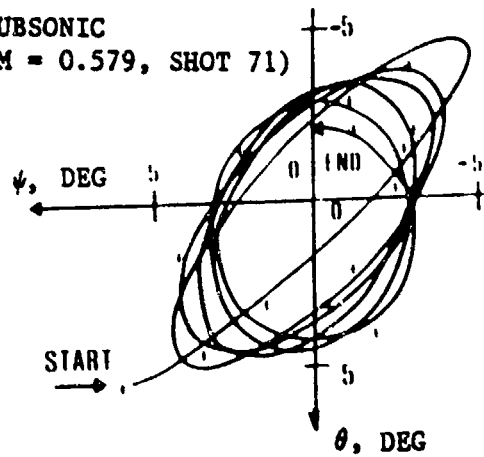
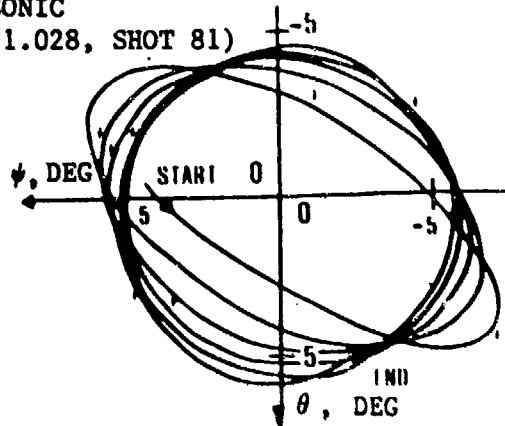


FIGURE 35. AEROBALLISTIC RESEARCH FACILITY DATA ANALYSIS SYSTEM (ARFDAS)

SUBSONIC
($M = 0.579$, SHOT 71)



TRANSONIC
($M = 1.028$, SHOT 81)



SUPERSONIC
($M = 1.243$, SHOT 87)

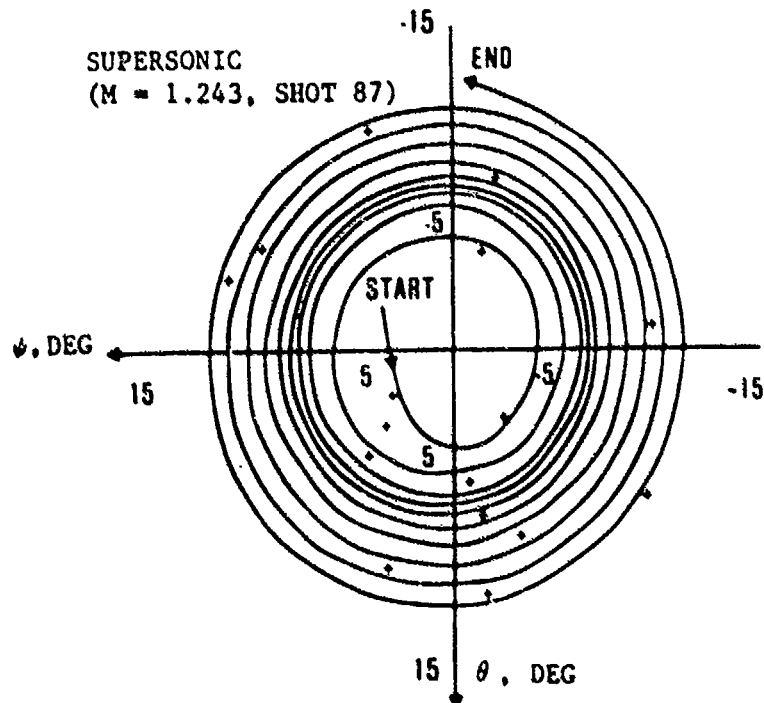


FIGURE 36. TYPICAL ANGULAR MOTION PLOTS

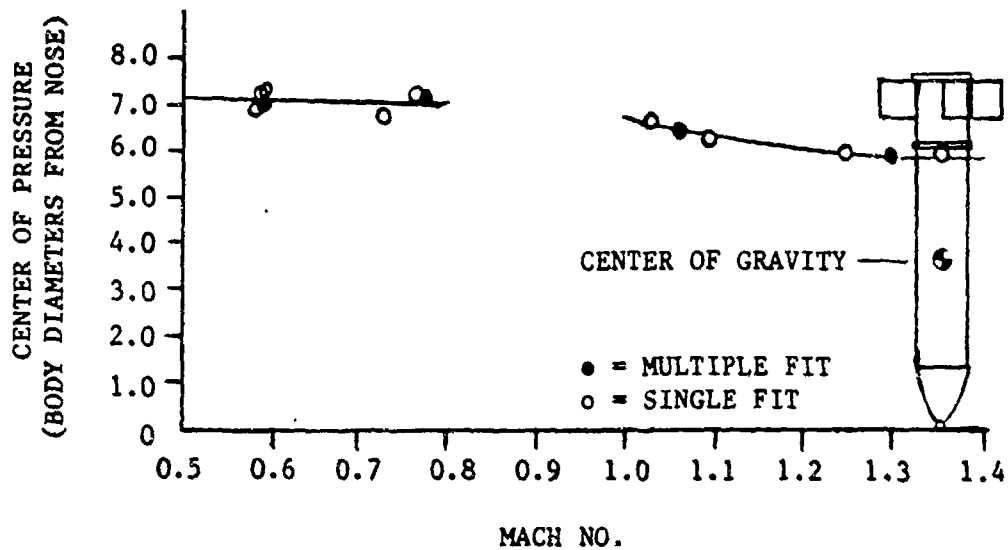


FIGURE 37. LOCATION OF THE CENTER OF PRESSURE

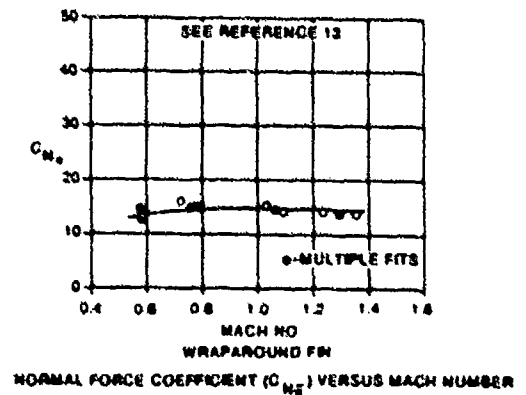
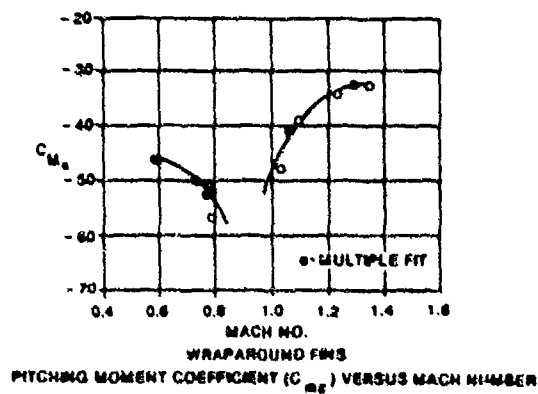


FIGURE 38. TYPICAL MISSILE DATA (CONCLUDED)

roll angle. Some of the coefficients can also be assumed to be functions of the flight Mach number. The nonlinearities with angle of attack are typically modeled as polynomial functions of the angle of attack or some trigonometric function of the angle of attack. Figures 37 and 38 show aerodynamic center of pressure, pitching moment, and normal force data derived from both single-fit and multi-fit methods available in ARFDAS.

The point of contact is Mr. Gerald Winchenbach, AFATL/FXA, Autovon 872-4085.

3. INTERIOR BALLISTICS LABORATORY

The Interior Ballistics Laboratory (IBL), consisting of: a fully enclosed firing tunnel; gun room, test control room, data acquisition room, static test room, loading room, and conditioning room; and, a propellant combustion laboratory, provides an integrated launcher and propellant technology development tool to support a wide range of munition systems program requirements. A test capability is available to support technology development requirements in such areas as follows:

- a. Gun system design and ballistic efficiency evaluation.
- b. Evaluation of ammunition designs.
- c. Evaluation of advanced propellant designs, including propellant tailoring, ignition systems, flash suppressants, catalysts, and combustion.

The facility houses all of the equipment necessary to conduct a full spectrum of interior ballistics tests, including evaluation of candidate design hardware and research/development associated with the physics of interior ballistics. Primary facility components include: a variety of specialized gun components, including both operational and experimental combustion chambers and barrels, mounting hardware, and support systems; projectile assembly and launcher charge preparation and preconditioning, instrumentation and data recording equipment designed for the highly dynamic and severe test environment associated with propellant combustion; and, data processing and reduction software to provide time-resolved experimental data for subsequent analysis and design utilization.

a. Launcher Hardware.

The IBL has a current capability to provide test data for ammunition sizes ranging from 0.50 caliber to 30 millimeters. The majority of laboratory test firings have been conducted using Mann barrels, designed with extra large diameter barrels having a very high pressure capability for experimental ammunition and propellant system testing. Various gun sizes are accommodated to a reinforced concrete block stand by means of a steel cradle.

b. Projectile and Propellant Charging.

A wide variety of spin-stabilized and non-spinning projectiles can be utilized for testing to provide realistic in-bore acceleration dynamics in response to propellant burn transients and chamber pressurization histories. Projectile position-time history is known to couple significantly with chamber pressure behavior, and correct in-bore acceleration response is an important aspect of

interior ballistics studies. Projectiles can be launched as provided or modified for particular test requirements. Projectile modifications, loading, and assembly is accomplished in a dedicated loading room.

The Interior Ballistics Laboratory has the capability for thermal conditioning projectiles to be tested. A conditioning room contains two ovens and two refrigerators that provide temperatures necessary for conditioning per military specifications.

c. Instrumentation.

The typical ballistic cycle is characterized by an early time pressure rise to a level on the order of 0.07 kilobar, followed by a rise to peak pressure in the 0.07 to 7.0 kilobar range. The combustion environment is further characterized by high temperatures, reaching several thousand degrees Kelvin. The complete ballistic cycle duration is of the order of 7.0 milliseconds, although the dynamic phenomena of greatest importance often occurs in the microsecond to millisecond time span. The experimental task, therefore, is to make high-pressure and high-temperature measurements in very short time intervals. This requirement leads to a need for rugged, high-dynamic range measurement transducers and high-speed recording equipment.

Typical experimental measurements include chamber and launch-tube pressure history, action time (time from ignition pulse to projectile muzzle exit), muzzle velocity, barrel and gas temperature, and projectile in-flight photographs. Pressure measurements are made typically utilizing high-pressure, dynamic pressure transducers. The transducers used are capable of operating in a transient, millisecond duration, thermal environment of up to 3000 degrees Kelvin. Calibrations are conducted utilizing actual test electronic cabling and components to provide high-confidence measurements. High-speed digital transient records are available to store and display test measurements. Figure 39 illustrates typical pressure measurements acquired for a 254-cm-long, 20-mm-diameter launcher instrumented with a single combustion chamber pressure transducer and two additional in-bore pressure transducers, located at one-quarter and one-half barrel length.

Launchers used for propellant evaluation can be configured with thermocouple ports for measurement of gas temperature and barrel surface and in-depth temperature history. Thermocouples typically utilized have a rise time of 10 microseconds or less and are capable of withstanding a pressure level of 3.45 kilobar and temperatures of up to 1500 degrees Kelvin.

Projectile muzzle velocity and overall ballistic-cycle action time is of importance in many interior ballistics studies. Projectile in-bore position-time history is of importance in ignition and combustion studies because of the strong interaction resulting from the generation of additional free volume during projectile acceleration. Action time is recorded via a digital counter initiated at ignition (e.g., at primer contact by a firing pin) and terminated by response from a light-sensitive photocell having a field of sensitivity at the muzzle exit. Action time can be measured with an accuracy of 20 nanoseconds. In-bore position and time can be resolved utilizing piston-probe elements designed either to provide conductive-path initiation or to function as circuit breakwire elements when struck by a moving projectile. Breakscreens and x-ray shadowgraphs are used to provide in-flight velocity and trajectory dispersion measurements.

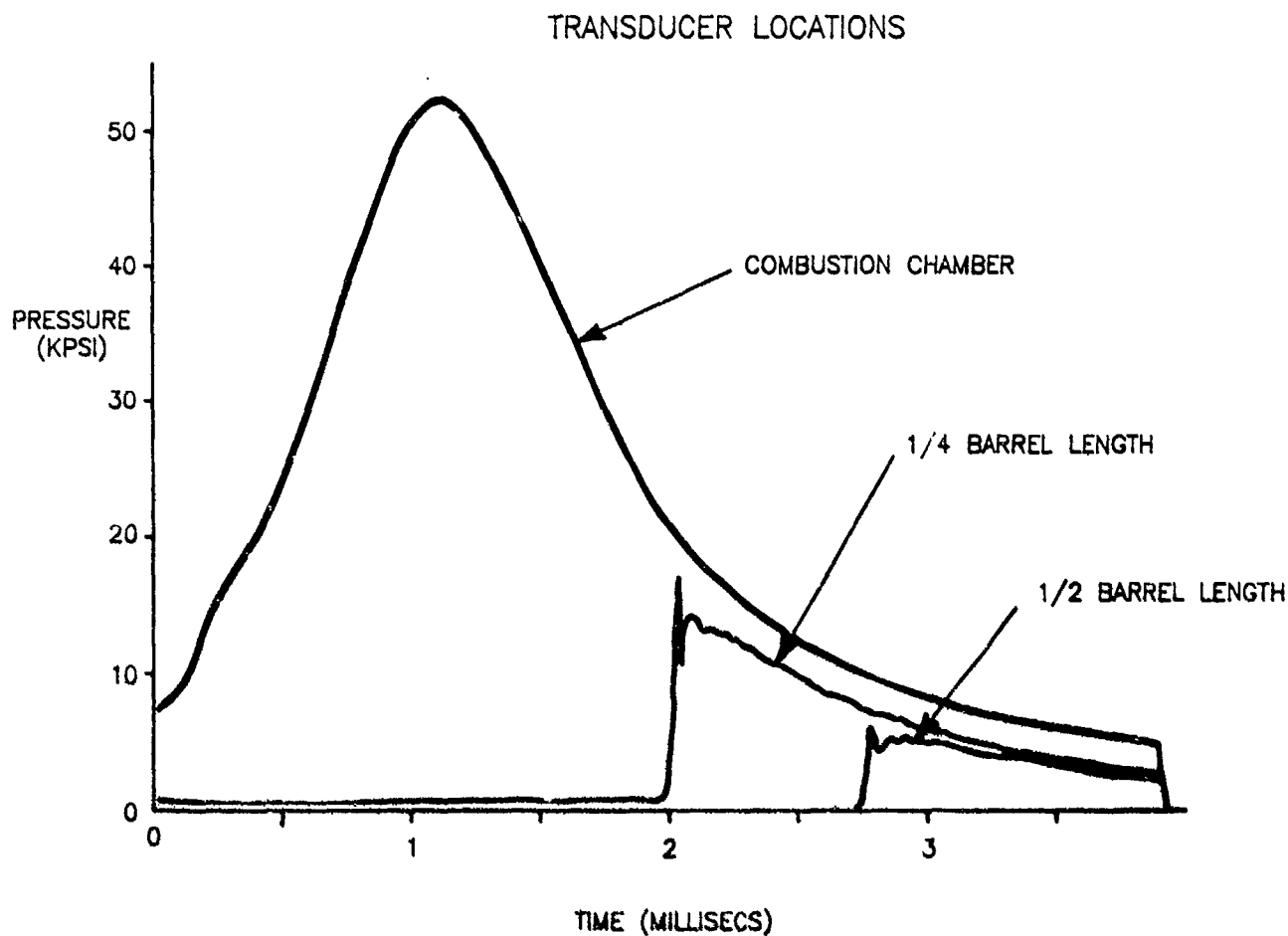


FIGURE 39. EXPERIMENTAL PRESSURE HISTORIES

REFERENCE

Heiney, O. K. and West, R. J. "Interior Ballistics, Muzzle Flash and Gas Gradients of Aircraft Cannon," AFATL-TR-76-34, Air Force Armament Laboratory, March 1976.

For determining projectile in-flight surface characteristics, a still photo camera with a Polaroid adapter can be operated with a microflash strobe unit to provide high-speed, high-resolution multiframe photographic data. The microflash strobe generates a one-microsecond light pulse to produce essentially stop-action photographs. These photographs are extremely useful for evaluating post-launch physical integrity of projectile surfaces, e.g., the effects of bore rifling on rotating bands. In addition, a Hycam camera, capable of producing 22,000 frames per second, is available for high-speed photographic requirements.

The point of contact is Mr. Gerald Winchenbach, AFATL/FXA, Autovon 872-4085.

4. GUIDANCE AND CONTROL LABORATORY

The Guidance and Control Laboratory was established to provide the capability to test and evaluate developing weapons guidance and control technology. It has the capability to test and evaluate inertial navigation hardware and to design and evaluate guidance and control software. Laboratory engineers also develop the custom software required to evaluate the variety of inertial sensors and systems being developed by defense contractors.

The testing of inertial navigation hardware is accomplished by the use of a Contraves Model 57A Programmable Rate Table and a Model 30H Control Module. Test data are collected using a Honeywell 1858 oscillograph and down loaded to a Digital Equipment Corporation (DEC) Micro-Vax II for further evaluation and correlation. Software development and evaluation is also accomplished on the Micro-Vax II computer.

In addition to the present facilities, a mobile test bed is currently under development. The mobile test bed will utilize a hybrid Global Positioning System (GPS) receiver. The receiver will be used in conjunction with guidance computers to evaluate the parameters of guidance systems and related equipment under development.

The point of contact is Mr. Pete Wise, AFATL/FXG, Autovon 872-2961.



FIGURE 40. GUIDANCE AND CONTROL LABORATORY

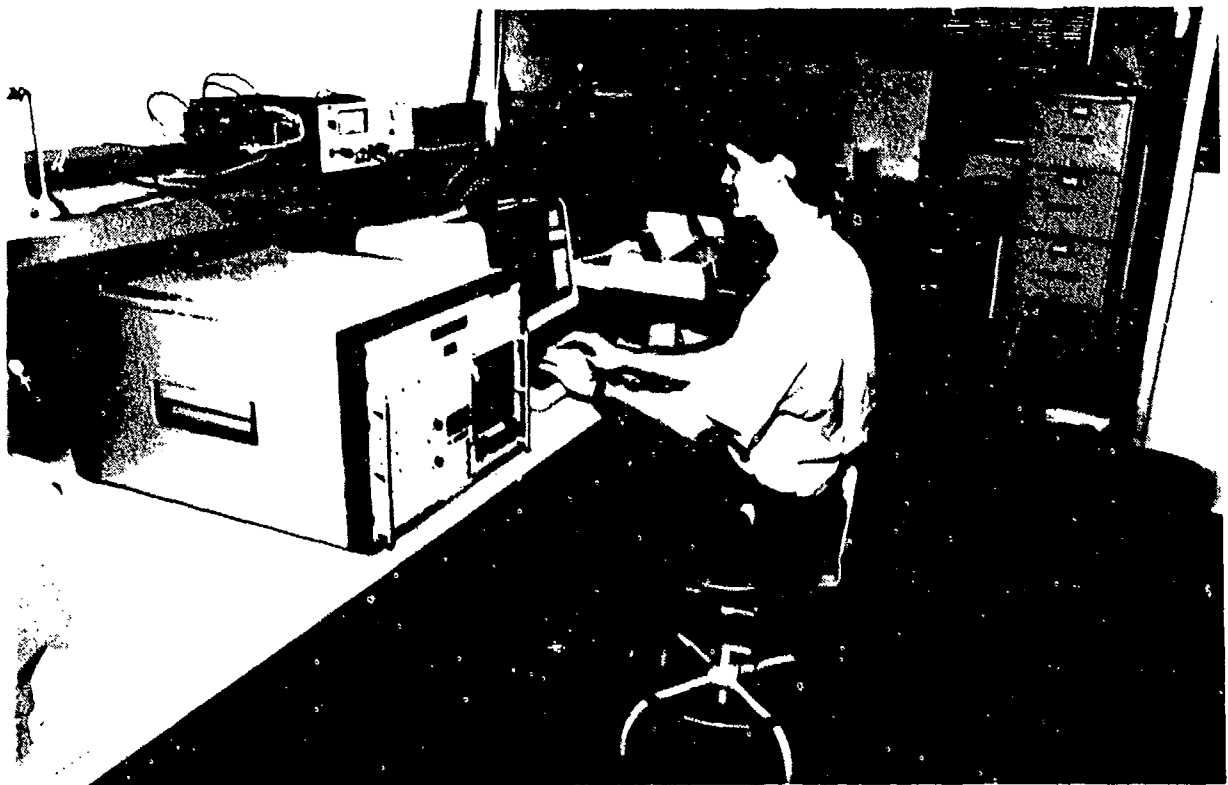


FIGURE 41. CONTRAVES PROGRAMMABLE RATE TABLE AND CONTROL MODULE

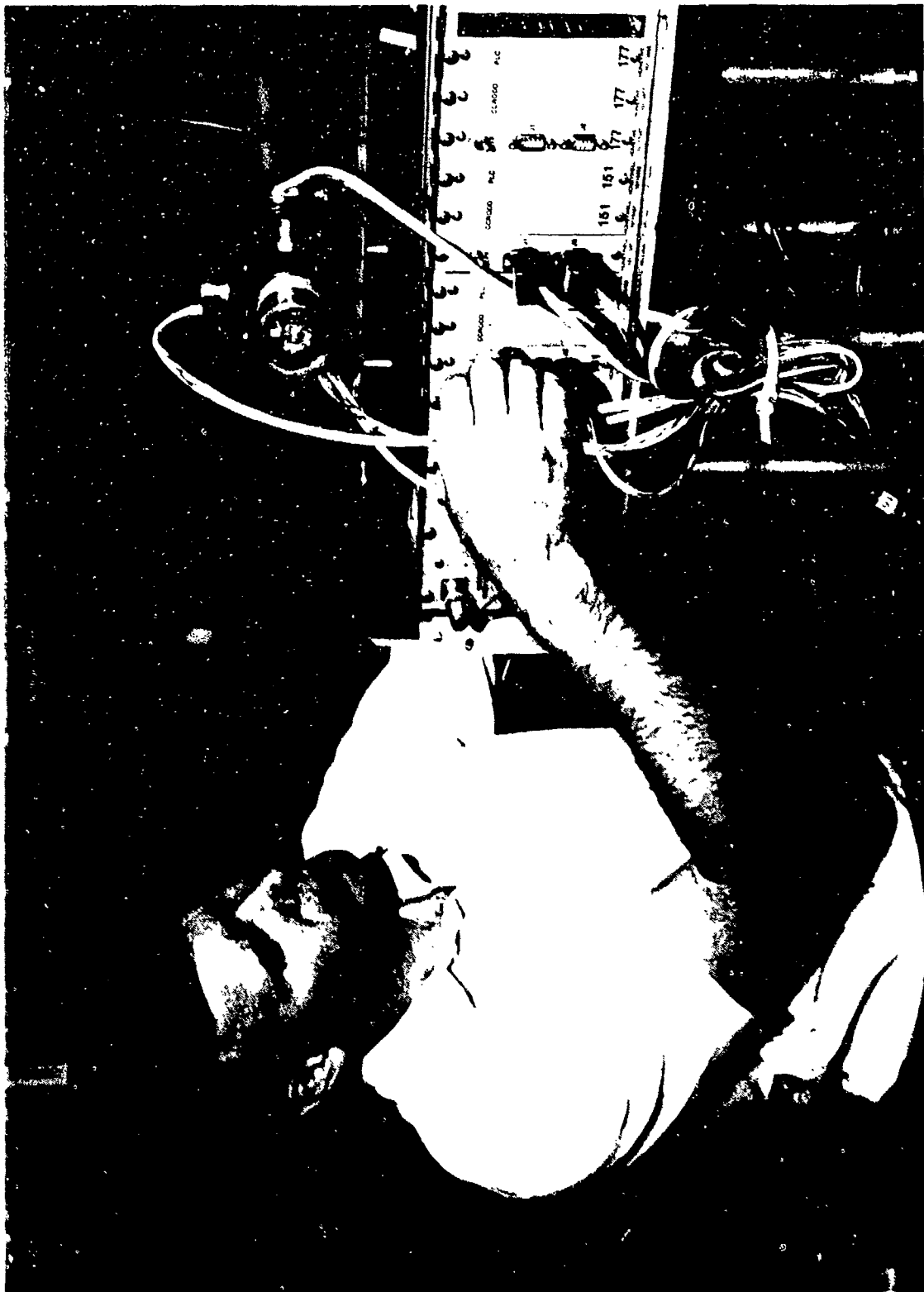


FIGURE 42. MINIATURE RING LASER GYROSCOPE

5. CARRIAGE AND RELEASE TEST FACILITY

The Carriage and Release Test (CART) Facility is a fully operational test laboratory capable of measuring ejector mechanism performance parameters and operating characteristics with various store configurations. Tensile strength testing of suspension lugs and other components can also be accomplished.

The CART Facility is fully equipped to do most ejection testing. An ejection test stand built over a foam-filled drop pit serves as a universal test fixture for ejector mechanisms, bomb rack units, pylons, and multiple ejector racks. Generic stores representative of 500-pound through 2000-pound weight classes are available for test purposes. The center of gravity and moment of inertia of these stores can be varied to simulate inventory items. Transducers are available to measure ejection and reaction forces, gas and fluid pressures, and store displacement, velocity, and acceleration. The transducers are connected to a PDP-11/24 computer which digitizes the analog signals, processes the signals, and stores the data on hard magnetic disks. Hard copies of the test data can be provided in both graphical or tabular format on a real-time basis.

Tensile testing is accomplished on a Tinius Olsen "Super L" Universal Testing Machine with a 400,000-pound load capacity.

The facility is located in Building 614, Bay 17, and is physically connected to the AFATL Model Fabrication Facility. This greatly enhances the facility's capability, in that special adapters and test fixtures can be quickly fabricated and installed with minimum impact on the test schedule.

The point of contact is Mr. Don Larson, AFATL/FXV, Autovon 872-2384.

6. COMPUTATIONAL FLUID DYNAMICS FACILITY

The Computational Fluid Dynamics (CFD) Facility was established to develop and validate CFD techniques for the design of advanced weapon airframes and analysis of weapon carriage/separation aerodynamic phenomena. The technical challenges require producing efficient and accurate gridding and flow solver techniques for unsteady subsonic-through-hypersonic viscous flow regimes for complex geometries. These calculations require that the facility be connected to a very large scale computer such as a CRAY. Development of methods for visualizations of the three-dimensional flow field using interactive color graphics are important to the validation and application of CFD. These calculations require very fast state-of-the-art three-dimensional graphic workstations.

The facility occupies an approximately 1,300-square-foot extension to Building 419, which was constructed in 1985. The facility houses 10 civilian and military engineers, three collocated technical, engineering, acquisition support (TEAS) engineers, and numerous visiting scientists and researchers throughout the year. The facility has an additional 700 square feet to house the graphic workstations necessary to complete the mission.

The facility consists of the following:

a. Two Silicon Graphics high speed three-dimensional color graphics workstations are available. An IRIS Model 3130 with 240 mega bit hard disk drive and both a cartridge tape drive and a 9-track tape drive is the most advanced workstation. An IRIS Model 3030 with 240 mega bit hard disk drive and cartridge tape drive is also available.

b. The facility also has two Tektronix 4129 and two Tektronix 4128 color workstations. These workstations are each configured with hard disk drives, as well as with dual floppy drive systems.

c. Hard copy capabilities for the color graphics exist in two Tektronix 4692 ink jet copiers and one Tektronix 4653 color copier.

d. Three Z-248 personal computers exist for communications with the business network and technical report writing. The Z-248's are each connected to a printer. Printers available include ALPS P2000G, Diablo 630, Quad Laser, and LN03+.

Numerical grids and flow solutions are obtained through batch operations on the CRAY-2 at the Air Force Supercomputer Center at Kirtland AFB. The grids and flow solution data files are either transferred to the CFD facility through the DDN and visually displayed on the IRIS workstations, or the data remain on the CRAY-2 and are visually displayed on the Tektronix workstations via in-house software developed to execute on the super computer.

Future plans are to connect the facility to MSD/KR via high speed fiber optic connection and to install a T1 line to MSD/KR from the Air Force Supercomputer Center. Both of these improvements will improve the data transfer rates to and from the facility. MSD/KR is upgrading the computer system locally at Eglin to include a very large scale computing system.

The point of contact is Dr. Bruce Simpson, AFATL/FXA, Autovon 872-3124.

SECTION V

ANALYSIS AND STRATEGIC DEFENSE DIVISION

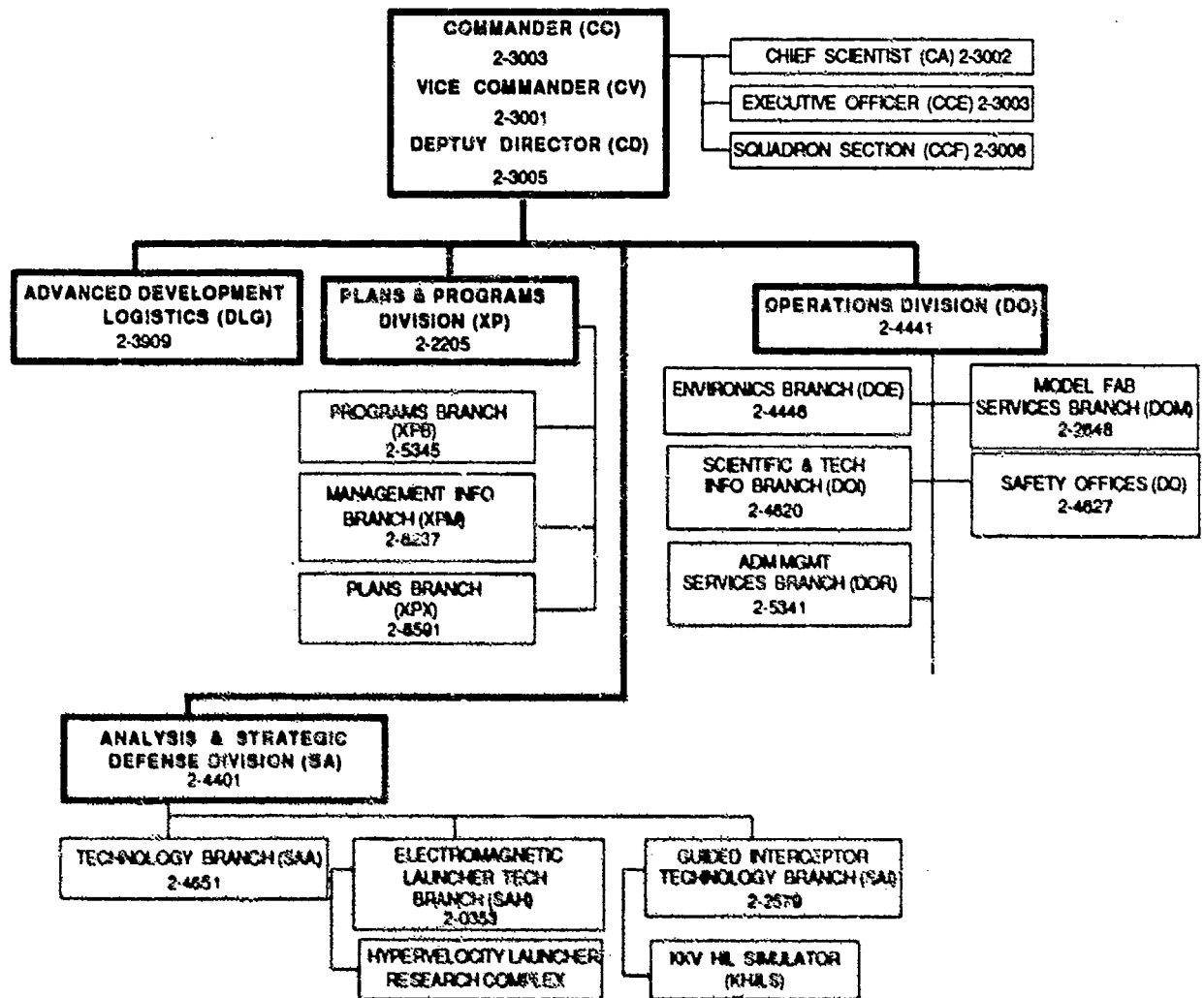


FIGURE 43. ORGANIZATIONAL CHART

1. MISSION OVERVIEW

The Analysis and Strategic Defense Division (SA) performs studies of threat target vulnerability and assessments in support of the Laboratory's technology development programs and operates the Hypervelocity Launcher Research Complex and the Kinetic Kill Vehicle Hardware-In-The-Loop Simulator (KHILS). This Division also develops and demonstrates technologies necessary for ballistic missile defense in support of the President's Strategic Defense Initiative.

2. HYPERVELOCITY LAUNCHER RESEARCH COMPLEX

The Hypervelocity Launcher Research Complex (HLRC) was established in 1984 to develop Hypervelocity Launcher (HVL) hardware to support the Strategic Defensive Initiative program -Kinetic Energy Weapons Technology:

Two major goals were established for the complex:

- a. Ground-based goal: Launch 5 kilograms (kg) at 4 kilometers per second (km/sec) with 40 MegaJoules (MJ) muzzle energy.
- b. Space-based goal: Launch 2 kg at 10 km/sec with 100 MJ muzzle energy.

Also, the complex should provide input to the lethality and interceptor groups for the selection criteria of projectile shapes.

a. Facilities.

Seventeen buildings comprise the HLRC area:

- #12510 Electronics Buildup Shop
- #12512 Engineering Support Facility I
- #12517 Engineering Support Facility II
- #12519 Supply/Equipment/Tool Shop
- #12521 Prototype/Battery Power Supply,
with a 12.2 meter (m) x 12.2 m gun bay
- #12522 Basic Research Facility (BRF) with two separate gun bays,
12.2 m x 12.2 m plus 4.6 m x 6.1 m
- #12526 Storage Building
- #12528 Contractor Support Facility
- #12531 Storage Building
- #12534 Storage Building
- #12549 Diagnostic Research, with a 7.6 m x 9.1 m gun bay
- #12550 Control Center
- #12551 Welding Shop
- #12553 Homopolar Generator, with a 4.6 m x 12.2 m gun bay
- #12555 Battery Power Supply (BPS) with a 18.3 m x 22.9 m gun bay with
a 12.2 meter height and access to the Gulf of Mexico firing range
- #12577 Storage Building
- #12588 Explosive Storage Building

The HLRC group was started in September 1984 at Range 22, and in October 1985 was moved to Site A-15 at Building 12522, the old BOMARC range used in 1957.

The three facilities (Homopolar, BRF, & BPS) provide power to rail gun launchers which vary in length depending on the total power supply energy released in one or multiple bursts.

Fabrication of switches, guns and power supplies, control of these energy sources and methods to handle the projectiles constitute the activity of these laboratories.

b. General System.

The hypervelocity launcher system requires two or more fixed rail conductors and a traveling armature which completes the electrical circuit between the rails. A high current is applied to this circuit, thereby creating magnetic fields that interact with the armature to accelerate the armature along the rails.

An armature forms a temporary conductive path connecting the conductive rails within the railgun. The conductive rails supply the current to this conductive path that can exist in one of three conditions: a plasma, a solid or a hybrid current conductor, all of which travel along the length of the railgun barrel. Each of the three conditions continue to accelerate the projectile until the projectile leaves the railgun bore. The induced speed of the projectile is dependent upon the launcher system energy transfer to the projectile. The length of the launcher is related to the power supply, impedance, and energy.

c. Basic Research Facility.

(1) The Basic Research Facility (BRF) functions as a high velocity/low mass test facility which provides three finite power supply types:

(a) A 5 MJ 11,000 volt (v) charged bank of capacitors where the capacitors are charged and then discharged into the railgun.

The rail launcher barrel lengths range from 1 to 5 meters and the bore of the guns range from 30 to 75 millimeters (mm). The rail launcher produces projectile velocities of above 2 km/sec.

b. A bank of eight 50KJ capacitor cans are utilized to test small bore Plasma Utility Guns (PUGs). These guns are 1 meter long with 10-15-mm bore sizes. These guns are used for material testing, both rails and insulators, and armature research.

c. A rapid fire system is used for high rate-of-fire testing. This unique system is powered by a module of low voltage capacitors that are charged between shots by a bank of batteries. Rapid-fire experiments are conducted with a clip-fed electromagnetic launcher (EML) powered by a battery-charged capacitor bank. The capacitor bank is powered by 160 automotive batteries. The battery/capacitor bank is capable of firing over 1000 shots. Plans include future tests incrementing to this number of shots. These experiments will provide a realistic environment to investigate the in-bore phenomena associated with firing multiple large bursts in rapid succession. The rapid fire EML has reliably and repeatedly produced 30-shot bursts at 5 Hz.

d. Diagnostic Research Facility.

This facility is utilized as an in-depth diagnostic research test facility which is used to further evaluate small bore guns. A bank of four 50KJ capacitor cans charged to 11,000 V powers the guns in this facility.

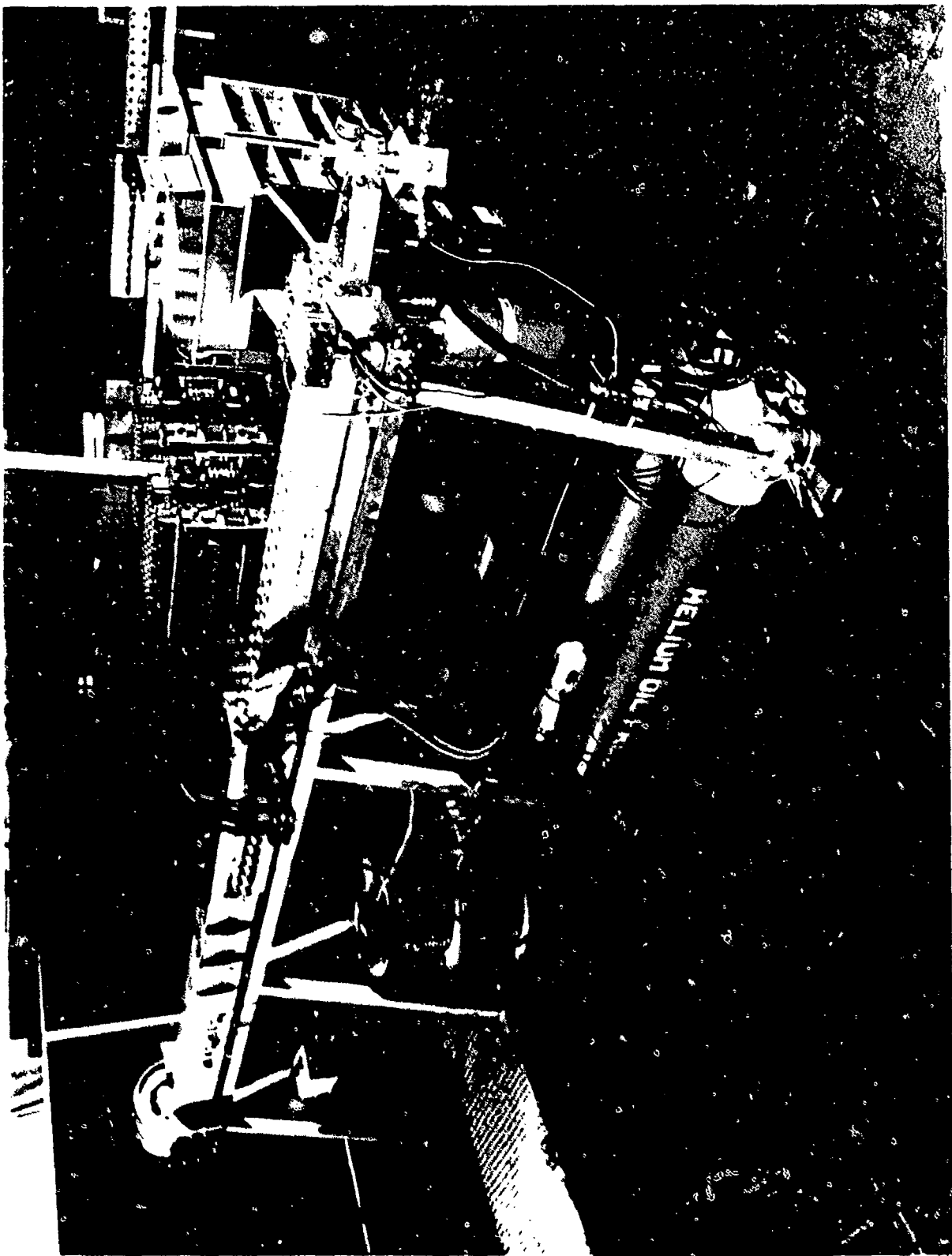


FIGURE 44. POWER SUPPLY, CAPACITOR, AND TARGET (WITH THE CAPACITOR
 IN POSITION, THE TARGET IS IN POSITION, THE TARGET FLIGHT RANGE, AND THE PROJECTILE CATCHER.)

e. Homopolar Generator.

The pulse-duty 10 MJ HemoPolar Generator (HPG) facility was built to test rapid fire launchers and the entire electromagnetic launcher system. It utilizes a liquid nitrogen cryogenic chamber to cool the induction coil. The coolant will eventually be liquid hydrogen to better duplicate space applications of the technology. The liquid nitrogen cools the induction coil and provides increased capability for rapid fire by producing a current pulse for 500 milliseconds (ms). The present rate of fire is 3 shots per 1/3 second at 10 MJ per 500 ms pulse and speeds currently approaching 3 km/sec.

The railgun utilized for the homopolar generator is 3 to 5 meters in length and has been fired with projectile diameters of 50 to 75 mm.

The advantage of the HPG is that the rotating generator occupies a relatively small area and provides 750 K-amperes for 500 ms.

f. Battery Power Supply (BPS).

The BPS facility houses 14,000 automotive batteries to provide 2.1 GJ now and 191 GJ in the future. Standard 12-volt batteries are connected in parallel or series combinations to provide the 102 or 204 v outputs at 2.5 Megaamperes (MA) rated at 200 MJ for a 5-second pulse width to the air core induction coil. The induction coil stores and shapes the energy pulse that is delivered to the railgun. The length of the railgun is 6 meters and will be 15 meters by November 1989.

The basic battery is an automotive battery rated at 850 Cold Cranking amperes which results in a 2000-ampere output for greater than 5 seconds or 11 kilowatts per battery. Lead-calcium chemistry battery design is utilized to minimize the gassing during charging cycles. Battery charging is automatically controlled to allow charging over a 24- to 48-hour period. The objective of controlling the charging cycle is to systemically bring all batteries to full charge by sets. This controls the rate of hydrogen gas production and allows for mixing and dilution of hydrogen from the batteries with air. The mixture is vented through the ceiling to prevent explosive concentrations of hydrogen.

The multiplexed control system monitors each battery for its health and charge state. The system allows the sets of batteries to be reconfigured around faults to allow for service as required. The 14,000 batteries will be expanded by 20,000 additional batteries to completely fill the battery storage area.

The BPS is the lowest cost energy source when rated as to the power efficiency in dollars per KJ. Space power supplies may need to provide a battery storage type output so that power is immediately available on a standby basis. Rotating machinery generators do not provide a quick response to action.

The air coil concept of BPS testing provides a land-based unlimited coil storage and no maintenance as compared to toroidal inductors which are more costly, complex, and difficult to maintain. The railgun is sized to provide for current densities of 3 MA to the 90 mm bore or 33 kA/mm.



FIGURE 45. 50-MM SQUARE BORE CHECKMATE RAILGUN (WITH A SINGLE SHOT HELIUM PREINJECTOR INSTALLED IN THE GUN BAY BELOW THE 5-MJ POWER SUPPLY).

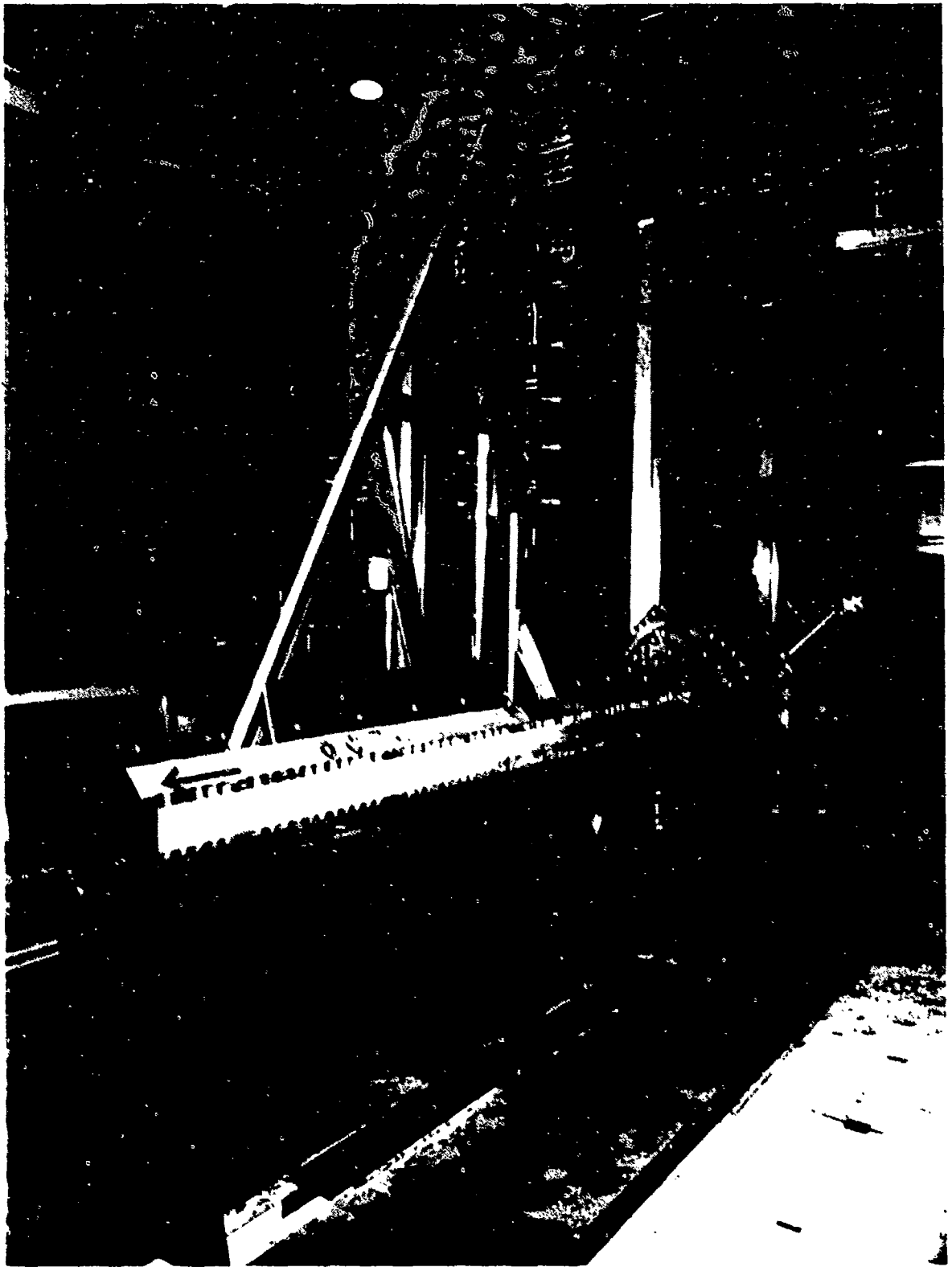


FIGURE 46. 75-MM 3-SHOT MARC IV RAILGUN (WITH 3-SHOT HELIUM PREINJECTOR INSTALLED IN THE GUN BAY OF THE BATTERY POWER SUPPLY).

Switching of the power to the railgun is first accomplished by means of a heavy duty contactor system with specially designed magnetic arc blowouts. The contactors connect the massive battery system to the main electrical bus. Next, a series of explosively actuated switches are progressively fired to interrupt the power flow and to create pulses of energy to the railgun. These switches are comprised of detonation cord charges attached to shaped aluminum bar stock. The detonation cord charge burns through the aluminum and opens the electrical path.

Key technical issues being researched by this facility include:

- Power Switching,
- Armatures,
- Barrel Life,
- Thermal Management,
- Hypervelocity,
- Sabot/Projectile/Armature Interface, and
- Rapid Fire.

The point of contact is Mr. Ray Starks, AFATL/SAH, Autovon 872-0207.

3. KINETIC KILL VEHICLE HARDWARE-IN-THE-LOOP SIMULATOR

The Kinetic Kill Vehicle Hardware-In-The-Loop Simulation (KHILS) Facility supports the Kinetic Energy Weapons Branch of the Strategic Defense Initiative Organization. The objective of the KHILS is to provide independent simulation and ground tests for space-based interceptors. A combination of digital and hardware-in-the-loop simulators are being stepwise developed to realistically simulate the launch-to-impact scenario for space-based guided interceptors. Actual brassboard hardware (seekers, signal processors, guidance processors, IMU's, etc.) will be interfaced into the simulation to provide both component and system level performance data.

In order to accomplish this objective, the Guided Interceptor Technology Branch has been divided into two laboratory facilities. The office area, located in Building 13, also houses the technology base portion of the facility. The technology base has responsibility for the initial engineering work as well as the development of concepts and ideas. The successful ideas are then sent to the Kinetic Kill Vehicle Hardware-In-The-Loop Simulator (KHILS) located in the basement of Building 13A.

The technology base is heavily involved in seeker technology for space based interceptors. Efforts are focused on target Signatures (Mid-Wave Infra Red (MWIR)/Long-Wave Infra Red (LWIR), and Ultra Violet (UV). The technology base is utilizing a digital seeker model to simulate various seeker concepts.

The KHILS is being developed in three phases: a baseline capability, flight experiment report, and system concept support. Phase one uses test equipment and test items generated under the INTELLECT Program. Phase two requires the development of a high resolution scene projector, high bandwidth flight table, atmospheric chamber, specialized data base, and a high speed disk system to provide formatted scenes for projection. Phase three will provide the necessary upgrades to the scene generation equipment and the projection

equipment, the table, and the data base to accommodate more stressing system concept environments.

The Test/Evaluation/Validation tasks take place in the KHILS. A major task of the KHILS is to simulate space based guided interceptors that have either been designed in-house or by contractors. The KHILS is currently in Phase One. It also contains the world's only scene projector for use in space-based, guided interceptor technology.

The Guided Interceptor Technology Branch has the only Government laboratory facility of its type and capability in the country. Several outside contractors are developing laboratories to provide different capabilities to be used earlier in the development phase of space-based interceptors; however, all final testing and evaluation is performed in this facility.

The point of contact is Mr. Lee Murrer, AFATL/SAI, Autovon 872-3160.

SECTION VI OPERATIONS DIVISION

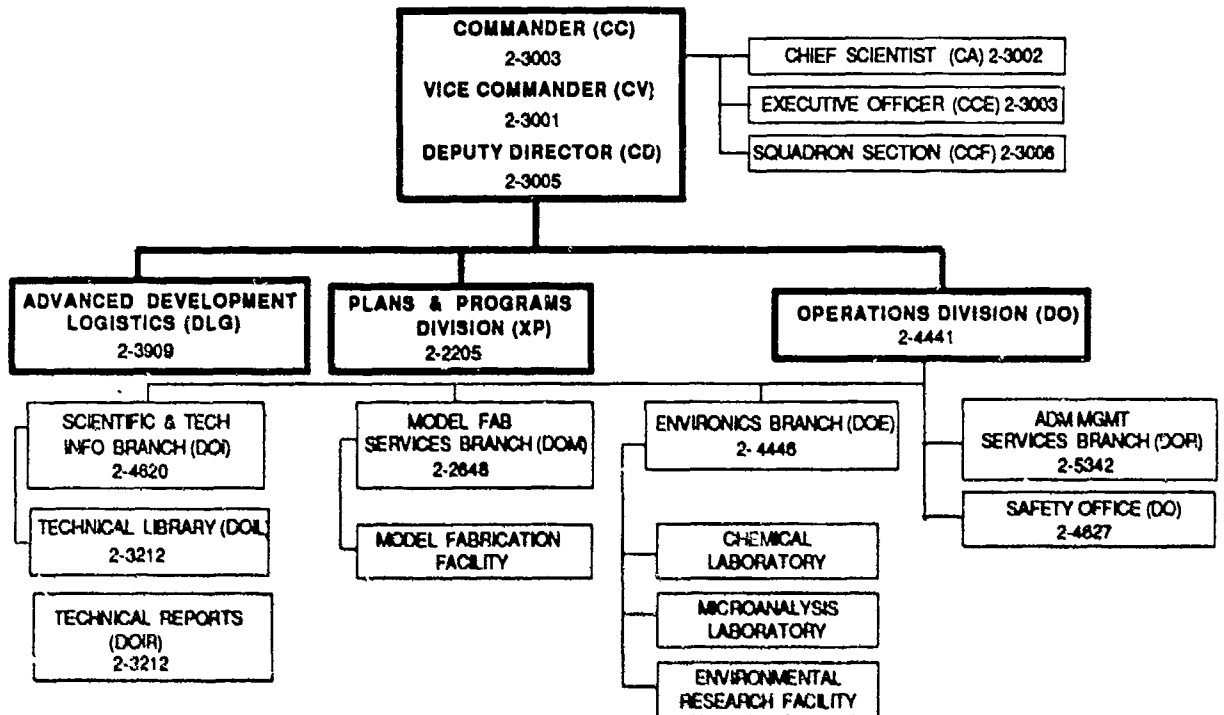


FIGURE 47. ORGANIZATIONAL CHART

1. MISSION OVERVIEW

The Operations Division (DO) manages the AFATL Environmental Quality Program, material resources, supply and logistics, and administration support; the operation of the chemistry laboratory, environmental research facility, microanalysis laboratory, and the model fabrication facility; administers the AFATL explosives / ground / system safety, security, and visitor control programs; manages the Scientific and Technical information program, which consists of the Technical Library and the Technical Reports Section, and coordinates requirements for minor construction, building maintenance and repair, and communications support.

2. MODEL FABRICATION FACILITY

The Model Fabrication Facility, known as the Model Shop, was established to provide rapid response to scientists and engineers of the Air Force Armament Laboratory in research, exploratory and advanced development type modeling work. Areas of responsibility include air-to-air and air-to-ground missile/weapon fabrication, aeromechanic shapes for wind tunnel investigations, fit test models, gun projectiles, modular weapon interface units, and suspension and release prototype hardware. These models consist of full scale and reduced scale sizes.

The Model Shop has been operational since August 1970. It is located in Building 614 which provides 20,000 square feet of room space. Personnel in this shop are highly skilled in two or more trades. In addition, they have broad experience and background in performing extremely accurate work. The trades utilized in this shop include machine, sheet metal, welding, fiber glass/plastic, numerical control machining, and quality control/measuring. The shop is organized functionally by these trades.

a. Machine: Machine work constitutes approximately 80 percent of the in-house support to the Air Force Armament Laboratory. The jobs performed vary from tiny precision machine parts to large assemblies and subassemblies. Machine surface finishes are less than 125 micro finish, and the shop has the capability to either grind or polish machine parts to a mirror finish. In addition to this, all explosive material in the laboratory that requires machining is accomplished by the Model Maker (Machinist). These tasks are accomplished in Building 1206 which is a part of the Energetic Materials Branch.

b. Sheet Metal: This section has the capability to cut and work material up to a 3/8-inch thick mild steel with power machines. Assemblies and subassemblies are produced with aircraft hardware, all types of rivets, and spot welding. Examples of munitions and explosives devices produced are full scale air-to-ground missiles and a variety of explosive molds.

c. Welding: This section has the capability to accomplish all types of welding on all types of material, varying from small needle-type soldering tasks to heavy target and target box construction up to 12 feet long and weighing 6 to 8 tons. The base motor pool supports projects of this magnitude by providing forklifts, lift trucks, and other heavy equipment as required. Heat treating can be accomplished on almost any item manufactured by the shop.

d. Fiber glass/Plastic: This section has the capability for making models of fiber glass or plastic, or a combination of these materials, as well as joining with metal parts to achieve a given objective. For example, all types of sabots are manufactured using ISAFOAM or a combination of ISAFOAM, fiber glass, and metal. These precision models have an excellent eye appeal and are used for briefing programs. A honing type finish can also be applied to metal surfaces by a sand blasting unit, using a 300-micro size aggregate. Although this does not prevent rusting, it is an excellent finish to prevent glare and provide a nice eye appeal or professional-type finish.

e. CAD/CAM System: This system has the capability for designing and programming scale models of missiles, targets, weapons, or any machined product having curved surfaces and/or exotic configurations that are impossible to design and machine by the conventional methods. The information can then be transferred to the numerical control machine center direct or by punched tape to manufacture the end item.

f. Numerical Control Machining: This section has the capability for manufacturing scale models of missiles, targets, weapons, or any machine product having curved surfaces and/or exotic configurations that are impossible to machine on conventional machine shop equipment. The accuracy and repeatability of products are held within 0.0005 inches.

g. Quality Control/Measuring: This section has the capability for verifying models that are procured from industry or from other Government agencies as well as those produced in-house. Prototype models for test purposes can be reproduced in this section from an original model without damaging the original.

The point of contact is Mr. Ralph B. Wade, AFATL/DOM Autovon 872-2648.

3. SCIENTIFIC AND TECHNICAL INFORMATION BRANCH (STINFO)

The Air Force STINFO Program, as an integral part of the DOD STINFO Program, ensures that STINFO generated by research, development, test and evaluation (RDT&E) programs is used to advance Air Force, DOD, and national R&D efforts. The exchange of STINFO eliminates duplication of effort, improves management efficiency, and supports those information needs of scientists, engineers, and managers.

The principal objective of the Air Force STINFO Program is to improve the scope, efficiency, and effectiveness of generating, collecting, processing, disseminating, and applying STINFO. The STINFO Program requires maximum participation in and compatibility with information programs of DOD activities, other federal agencies, and the private sector. The overriding priority of the Air Force STINFO Program is to ensure that all STINFO generated by, or relevant to, Air Force research and engineering (R&E) programs is exchanged rapidly and effectively among Air Force and other DOD managers of R&E, Air Force contractors, and potential contractors. The governing regulation for the Air Force STINFO Program is AFR 80-40

The point of contact is Ms Lynn Wargo, AFATL/DOI, 882-3213.

The Technical Library supports the research, development and testing functions of the Laboratory, the Munitions Systems Division, tenant agencies and their contractors. The collection includes books, journals, technical reports (classified and unclassified), studies, documents, and miscellaneous printed and filmed materials. It is composed of approximately 18,000 books, 800 periodical subscriptions (300 of which are in direct support), 20,000 bound periodicals, 30,000 reels/cartridges of microfilmed periodicals, and 500,000 technical reports (hard copy and microfiche).

Major subject fields covered in the collection are aeronautics, atmospheric sciences, chemistry, civil engineering, communications, computer sciences,

detection and countermeasures, electrical engineering, electronics, environmental sciences, management, materials, mathematics, mechanical engineering, military science, missile technology, navigation, ordnance, and physics.

Services include on-line and manual literature searches, reference, referral, bibliographies, and interlibrary loan. The library's on-line access capability currently consists of the following:

a. DROLS - The Defense Research On-Line System accesses the three data bases of the Defense Technical Information Center (DTIC - formerly DDC).

The DD Form 1473 (now replaced by the SF298) or technical report file contains over a million and a half records of technical reports generated as a result of research and development by the DOD, universities, research centers, civilian contractors, and information analysis agencies. Project managers must have a search run against this data base at the outset of a new work unit to determine the state of the art for their project.

The DD 1498 or work unit file holds about 144,000 work units; new, changed, terminated, and completed. This data base is valuable for determining the current and ongoing work being done throughout the DOD and NASA which parallel local work.

The DD 271 base (Independent Research and Development or IRAD) gives the view of in-house, contractor funded, work being done in support of the DOD. The data are proprietary and solely for the use of the DOD. Project managers must also have a search done in this file at the start of a new work unit to determine who among the contractor community may be doing the kinds of research/development which might be applicable to their projects. Input to the data base was begun in 1976 and there are now almost 50,000 records in the file.

b. DIALOG - A product of Knight-Ridder Information Systems which provides on-line interactive search access to more than 200 commercially available bibliographic and nonbibliographic data bases. Searches are fully retrospective, covering all of the years that the data bases have been available. Of particular interest to the Eglin R&D community are Chemical Abstracts, Compendex (Engineering Index), Congressional Information Service, Enviroline, ERIC, INSPEC, Management Contents, METADEX, NTIS, NEWSEARCH, SCISEARCH, the Smithsonian Science Information Exchange (SSIE), and SPIN (American Institute of Physics).

c. OCLC - A not-for-profit on-line system that provides technical support services for cataloging and interlibrary loan. An on-line union catalog gives access to more than 18 million cataloging records which can be used by member libraries for cataloging new books and journals and for acquiring printed catalog cards. The system is also used for locating materials not owned by the AFATL Technical Library and then processing the interlibrary loan request.

The library also provides liaison with other federal scientific and technical information centers, universities, and private industry information activities.

The point of contact is Ms June Stercho, AFATL/DOIL, 882-3212.

The AFATL Technical Reports Section manages the technical reports program and serves as an integral member of the research and development team. The Technical Reports Section has the capability of supporting professional editing/writing, technical illustrations, and administrative expertise in all aspects of report processing.

The point of contact is Mr Jim Krug, AFATL/DOIR, 882-4476.

4. CHEMISTRY LABORATORY

The Chemistry Laboratory has been operational for 20 years. The primary mission of the Chemistry Laboratory is to support the munition technology programs and the environmental assessment requirements of the Air Force Armament Laboratory. The Laboratory also provides support to other Munition Systems Division Organizations as requirements arise.

The Chemistry Laboratory is a general purpose facility equipped for classical wet chemistry and instrumental analyses. This Laboratory also has the resources to perform many nonroutine analyses. The facility consists of general purpose analytical equipment as well as some of the most sophisticated analytical instrumentation available. This instrumentation is used to quantitatively determine contaminants in chemicals, explosives, fuels, soils, or water. The Chemistry Laboratory is capable of determining residual levels of metal contaminants in samples down to the parts per billion level. The following is a list of some of the analytical instrumentation the Chemistry Laboratory utilizes to support its mission:

- a. Inductively Coupled Plasma Emission Spectrophotometer (ICP).
- b. Atomic Absorption (AA).
- c. Gas Chromatography (GC).
- d. Infrared Spectrophotometer (IR).
- e. Ultraviolet Spectrophotometer (UV).
- f. Total Organic Carbon Analyzer (TOCA).
- g. Kjeldahl Nitrogen Analyzer.

Samples are extracted, processed/purified, and then subjected to analytical techniques such as GC, ICP or AA. Data are input and acquired through terminals and computers associated with these instruments. Data are then compared with data from known standards of predetermined concentrations.

A typical evaluation performed by the Chemistry Laboratory might be a soil analysis. Soil samples are collected from a test range that was used for testing unique warhead materials. The soil samples are chemically extracted, purified to remove interfering compounds, and then analyzed using an AA, GC or ICP. These techniques will determine the residual levels of metals or organic breakdown products in the soil.



FIGURE 48. INJECTING SAMPLE INTO GAS CHROMATOGRAPHY WATER POLLUTION ANALYZER



FIGURE 49. MEASUREMENT OF VISCOSITY USING A VISCOSITY BATH AND VISCOMETERS

Examples of research conducted by the Chemistry Laboratory include the following:

- a. Analysis of lead, uranium, and other metals in air, soil, water, vegetation and biological tissue.
- b. EPA water quality analysis.
- c. Analysis of residual levels of organic and inorganic compounds in soil, water, and biological tissue.
- d. Analyze the purity and aging effects of explosives.
- e. Determine contaminants in fuels, soils, and water.
- f. Density and volume analysis of solids and liquids.
- g. Measurement of physical properties such as boiling point, melting point, flash point, freezing point, and vapor pressure of various materials.
- h. Physical and chemical analysis of petroleum products.
- i. Verify the chemical purity of organic and inorganic compounds.
- j. Moisture, corrosion and fungus analyses.
- k. Viscosity, turbidity, conductivity and pH measurements of liquids.
- l. Measurement of refractive indices and thin film thickness.
- m. Total organic carbon analysis.
- n. Nitrogen analysis.
- o. Identification of unknown chemicals and compounds.

This laboratory is the only general purpose chemistry laboratory on Eglin Air Force Base; therefore, no parallel efforts exist at Eglin. Parallel efforts exist in the Department of Defense (DOD) and the Environmental Protection Agency (EPA) for general chemical support, but many analytical efforts in support of munitions projects are unique to the Air Force.

The Chemistry Laboratory combines the latest in analytical instrumentation and sampling techniques to provide support to the Air Force Armament Laboratory as well as to other Munition Systems Division organizations.

The point of contact is Mr. Charles I. Miller, AFATL/DOE, Autovon 872-4446.

5. MICROANALYSIS LABORATORY

The Microanalysis Laboratory has been in operation for 20 years. The capabilities of the laboratory include the facilities and equipment for microscopic research, qualitative and semi-quantitative particle studies, metallurgical analysis and image processing. The primary functions of the laboratory are listed below:



FIGURE 50. IMAGE ANALYZER



FIGURE 51. COLLECTING SAMPLES AT MONITORING STATION, RANGE C-64C

a. Perform qualitative and semi-quantitative material analysis at the microscopic level. A scanning electron microscope (SEM) and X-ray spectrometer are used for this analysis.

b. Perform automated image analysis for material and particle studies.

c. Perform biological and chemical research to support environmental assessments and statements for conventional weapon systems.

d. Perform quantitative material analysis using X-ray fluorescence.

The SEM allows engineers to determine particle size distribution and morphology of propellants, explosives and debris from penetrator impacts against armor. In addition, microscopic physical characteristics of propellant and explosive formulations are analyzed. Semi-quantitative analysis and identification of materials above atomic number 5 (Bo) are performed by a Kevex energy dispersive spectrometer. This allows semi-quantitative identification of metal particles at the 1 micron level.

Image analysis is used to process SEM images to obtain the best pictures possible. These micrographs assist engineers in explaining microstructural characteristics of armor impacts, propellants, or explosives. This detailed engineering analysis improves manufacturing techniques and the understanding of fundamental processes. A typical evaluation conducted by the Microanalysis Laboratory follows.

A soil sample is collected after firing munitions against armor. The sample is sieved to remove large particles and subsequently subjected to a density gradient to concentrate the denser particles. The sample is then mounted on an aluminum stub and coated with a 200-angstrom layer of conductive material (gold). Finally the sample is analyzed using SEM and X-ray spectrometry. Micrographs produced from these techniques are used for detailed studies.

Examples of the research at this laboratory include the following:

a. Alloy sorting and identification.

b. Automated image analysis.

c. SEM and X-ray spectrometry.

d. Particle size distribution studies.

The Microanalysis Laboratory provides expertise and valuable studies on materials used for the Air Force Armament Laboratory and the Munitions Systems Division research and development test activities.

The point of contact is Mr. Luis Santana, AFATL/DOE, Autovon 872-4446.

6. RADIOCHEMISTRY LABORATORY

The Radiochemistry Laboratory has been operational for 15 years. This laboratory consists of a processing facility located at Test Area (TA) C-64C and an analytical capability located on Eglin Main in Building 13. The

mission of this laboratory is to conduct a wide range of laboratory and field support activities in the area of research, development and testing for heavy metals weapons technology. The Radiochemistry Laboratory has the capability of quantitatively analyzing and monitoring soil, water, air and biological samples for radioactivity.

Data acquired by quantitative field and laboratory research and monitoring are processed using specialized instrumentation and computers. The processed data are then used to prepare documentation to insure compliance with all local, state, and federal regulations and laws.

A typical evaluation conducted by the Radiochemistry Laboratory would include collection of soil samples from a test range monitoring station where depleted uranium (DU) munitions are being tested. These samples are then taken to the laboratory to be processed and measured for radioactivity using a cadre of sensitive low level counting instruments and computer data analysis. These data aid AFATL in obtaining and complying with radioactive material permits and licenses required by local, state, and federal agencies and in the protection of the environment and personnel.

Examples of research done by this Laboratory include the following:

- a. Environmental monitoring of munitions testing.
- b. Determining and monitoring of radiation levels in soil, water, air and vegetation.
- c. Life cycle testing of conventional ammunition.
- d. Warheads research using DU.

The Radiochemistry Laboratory brings together diverse capabilities in field and laboratory research and routine monitoring of the environment using state of the art equipment and expertise that allows the Air Force to work in conjunction with other professional and governmental agencies in the area of environmental and occupational health protection.

The point of contact is Mr Richard Crews, AFATL/DOE, Autovon 872-4446.

7. ADMINISTRATIVE MANAGEMENT SERVICES BRANCH

a. Personnel (Military and Civilian): This section is the focal point of all personnel actions for everyone assigned to the Air Force Armament Laboratory. Civilian personnel includes the hiring of employees in vacant positions by supervisors; monitoring the civilian appraisal system for all General Scale and Wage Grade employees; the management of career progression promotions; and civilian time and attendance sheet management. A data base called an F-File is maintained on all authorized and assigned military/civilian employees in AFATL and is updated every 2 weeks. The personnel section is also responsible for in and out processing all military/civilian employees from AFATL.

b. Administration: This section handles a myriad of administrative duties to include Laboratory records manager; Privacy Act monitor; OES/EPR

Laboratory monitor; Laboratory awards and decorations manager; duty status monitor for the military; publication and distribution clerk; military leave program manager; compiling the Laboratory Commander's Monthly Information book; unit on-the-job training manager for the Laboratory; the AFATL forms manager; AFATL customer account representative; Technical Orders monitor and distribution of Technical Reports; Laboratory mail room responsibilities; Quality Assurance Evaluator alternate for AFATL; and, distribution clerk duties for both military and civilian personnel assigned to the Laboratory.

c. Training: The Laboratory Training Officer performs technical, specialized support work that involves providing training for scientists, engineers, and support personnel for both military and civilian personnel assigned to AFATL for enhancement of self-development and career development environments. The Training Section was lauded by the AFSC Inspector General Team for the outstanding AFATL Program Managers' Overview Course. Several other bases have made inquiries regarding the course for possible implementation at their installation. A audio/video cassette library was established for employees not readily available for on/off site training and is now being widely used throughout the Laboratory. The Training Section established a data base program for tracking: required training needs of all AFATL employees, (military or civilian) course dates, attendees, employees completing the course, and includes future courses for the year. Incumbent is appraisal as the Total Quality Management (TQM) Project Manager for AFATL and attends MSD Acquisition Process Improvement Team (MAPIT) committee meetings.

d. AFATL Orderly Room: The AFATL Orderly room is responsible for the military leave and weight programs; sponsorship program for incoming personnel; hospitalization program that handles all military dental and hospital appointments to include immunizations; military airman performance testing program; and the AFATL records clerk.

e. Security: The AFATL Staff Agency Security Manager provides advice and assistance to the AFATL commander and to all personnel assigned to the Laboratory. Develops required internal security operating instructions and ensures compliance. Ensures assigned personnel receive security education and develop annual security education training plans. Monitors internal semiannual security inspections. Requests and accounts for AFATL controlled and restricted area badges for the base. Reviews challenges to classification decisions and ensures security classification guides are kept current and reviewed biannually. Handles the proper reporting of all security violations, and insures required inquiries and investigations are conducted. Monitors the personnel security program actions. Also manages the COMPUSEC, COMSEC, TEMPEST, and foreign disclosure programs.

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